# banquete_

## nodes and networks

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*banquete_nodes and networks* is a work in progress designed to explore and stimulate interactions across art, science, technology and society. Conceived and developed by Karin Ohlenschläger and Luis Rico, the project enjoin us to explore the borderlands of Spain's emerging digital art in a dialogue with science and society that will, in its turn, open up avenues of cultural and technological transfer to and from Spain.

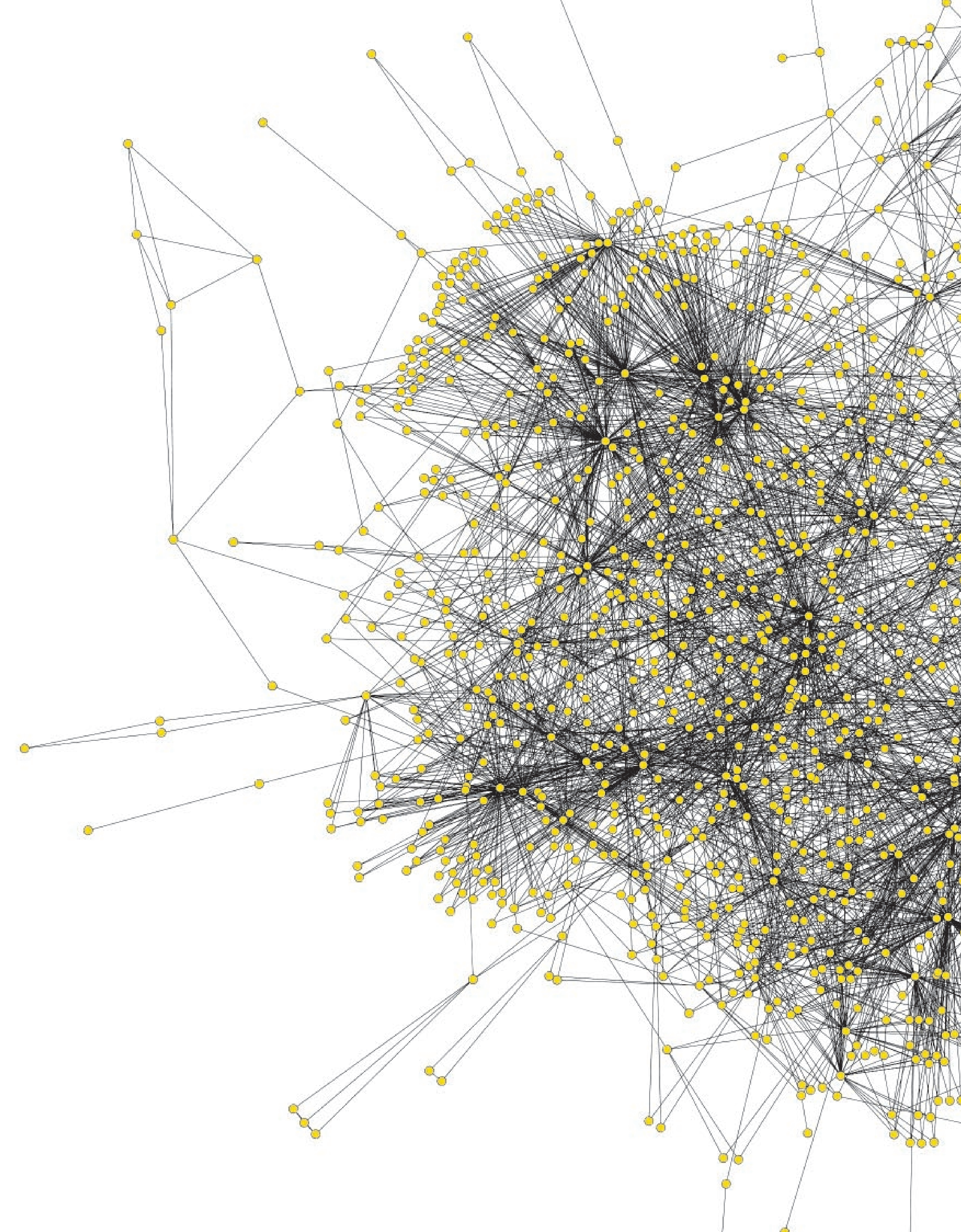
*banquete_nodes and networks* considers the network as an organising pattern that traverses all domains of our reality. From neuronal tissue to the dynamics of contemporary social flux, from the interplay of bacteria to digital information highways: these are but different strata in a single "network society", a realm of constant technological, scientific, social and cultural change that touches on us all. From the perspective of this new form of shared patterning, the project opens up a forum for dialogue and reflection on the global society.

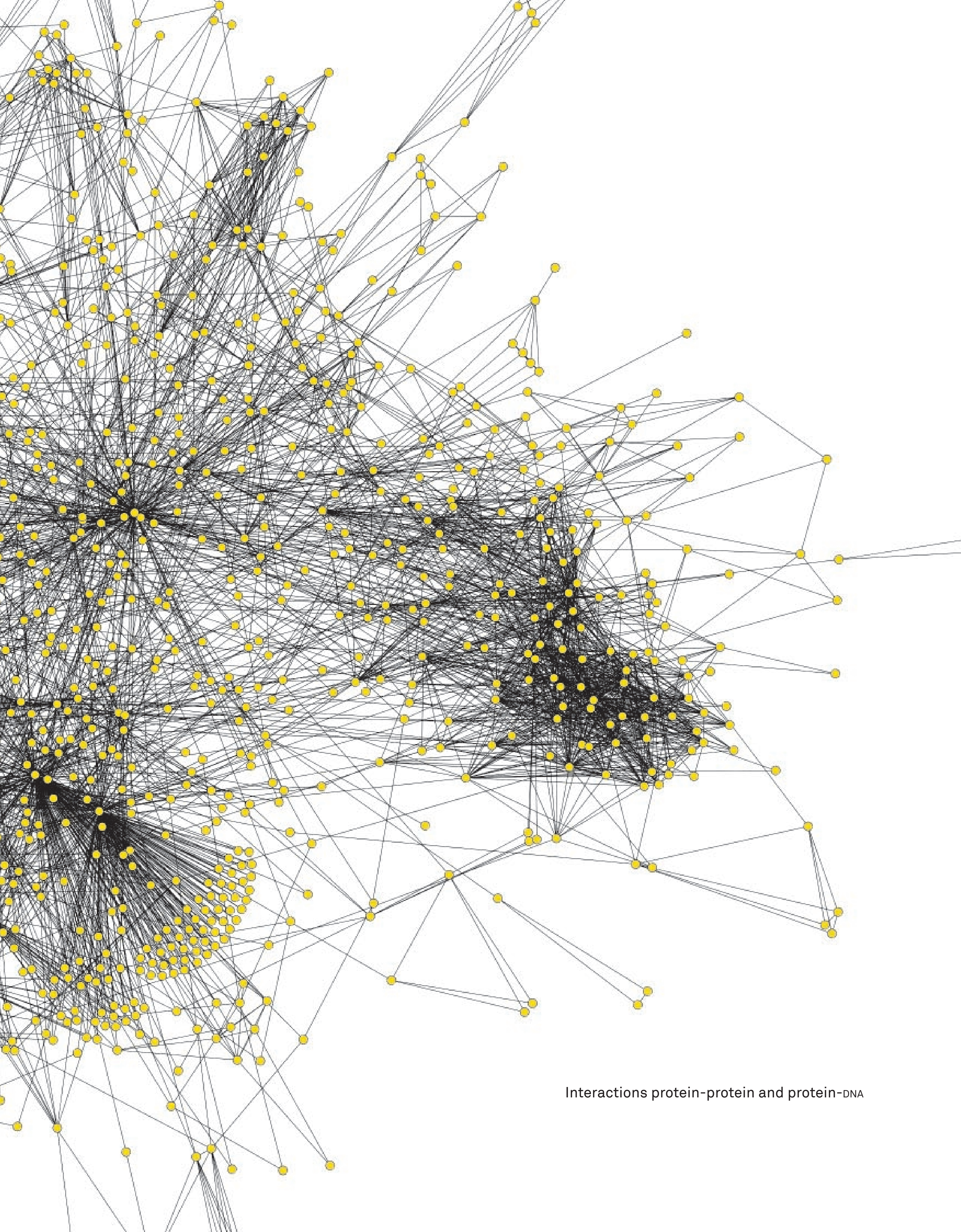
The ceaseless technological convergence in which we are all engaged requires that institutions devoted to culture and the arts join forces to produce fresh ideas. The search for innovative strategies and lines of approach urges us to scrutinize and process the interconnected complexity of contemporary societies. We need to cut new, cross-disciplinary paths that lead to a synergy of art, science, technology and society, and so lend shape to new forms of work, creativity and research, training and communication.

The institutions behind *banquete_nodes and networks* — SEACEX (State Corporation for Spanish Cultural Action Abroad), LABoral Centro de Arte y Creación Cultural, ZKM | Center for Art and Media Karlsruhe, and the Fundación Telefónica — seek to build networks and practices of cultural production and communication that articulate the output of the arts, technology and science in one and the same process of creation, thus fostering a vigorous culture of research, development and innovation.

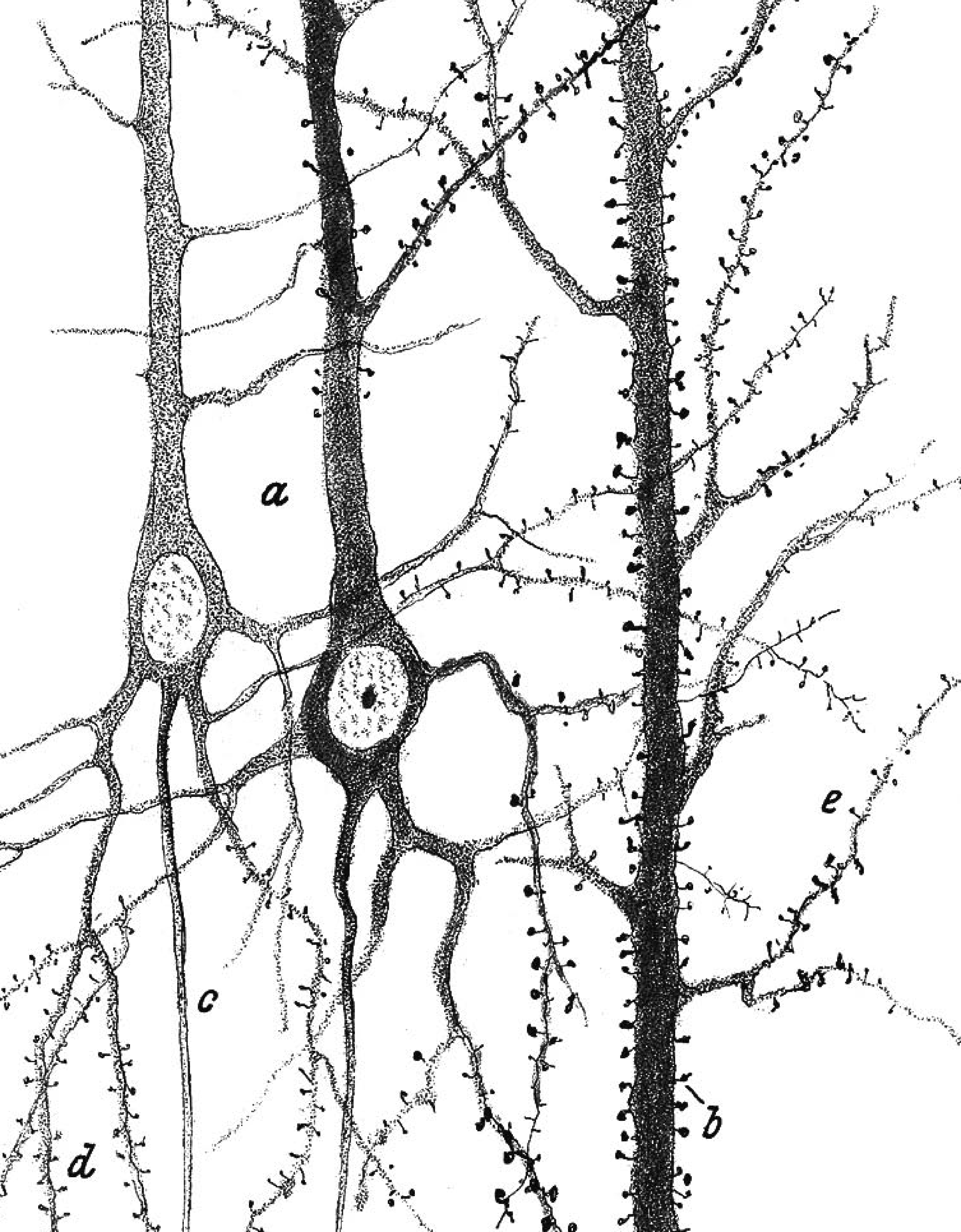
It is a great satisfaction for all of us to unveil this project, which brings together and interrelates the work of thirty artists and creative teams and of a similarly broad range of scientists, technologists, philosophers, thinkers and producers of knowledge, so as to embrace a wide diversity of creative practices. Their work invites us to make an intriguing journey across the landscape of Spain's digital culture today.

**Mercedes Álvarez**, Regional Minister of Culture and Tourism of the Principality of Asturias
**Peter Weibel**, ZKM Chairman and CEO
**Charo Otegui**, President of State Corporation for Spanish Cultural Action Abroad, SEACEX





Interactions protein-protein and protein-DNA


a
e
c
b
d

# From the neuron to "network society"

Karin Ohlenschläger, Luis Rico

This publication is the third part of a trilogy by the *banquete_* project, which explores relations between biological, social, technological and cultural processes. As in the two earlier editions, it brings together outstanding artists, architects, biologists, engineers, philosophers, economist, neuroscientists and sociologist to reflect on the dynamics, patterns and processes present in tangible and intangible flows of matter, energy and information. Our goal is to foster interaction among the sciences and humanities, and to question a reigning model of anthropocentric, linear and dichotomous thought whose political, social, economic, cultural and ecological consequences call for an urgent change of sensibility, outlook and behaviour. From this perspective, we propose an overview of the connections between art, science and other forms of knowledge production emerging recently in Spain. We invite you to visit the previously uncharted border regions defined by the interactions that constitute them. *banquete_* arose from a network of conversations between creators and researchers in various fields and disciplines who, since the 1990s, have been tracking the art-life binomial in the light of techno-scientific advances and in relation to emerging languages linked to contemporary creation. In 2003, the first edition of *banquete_* delved into the correspondence between life forms and forms of communication, exploring analogies between metabolism and communication as processes of transformation in matter, energy or information. In 2005, the second edition emphasized the evolutionary character of both processes, and the third and most recent edition has further studied the underlying reticular structures.

Barely a century separates Santiago Ramón y Cajal's discovery of the open, evolutionary character of the structure and functioning of neuronal networks and Manuel Castells' theory of "network society", but, in that time, society has undergone one of its greatest accelerations in all orders. Our dizzying techno-scientific, social and cultural transformation has configured a new paradigm based on both the complexity of multiple realities in which we operate simultaneously and the connections between processes and events previously considered autonomous, incompatible or simply incomprehensible.

This new scenario implies the structure of a network of networks, conceived of as our most highly perfected instrument for interpreting and understanding the diversity and complexity of contemporary experience. At the end of the 19th century the brain was able to observe itself, contemplating for the very first time its neurons and nervous system in an unprecedented exercise of reflexivity. And now, on the threshold of the 21st century, when global society is facing the need to rethink and reconstruct itself on the basis of a new paradigm, the absorbing reality of the web influences our ways of thinking and behaving. In fact, we are no longer the same since we realized that we are interconnected in all orders of human activity. Any pretense of autarky in the areas of knowledge or creation, and any closed cultural identity, grow progressively obsolete in this new space of transit and fluidity, whose very permeability constitutes a new way of

understanding and constructing reality. Through networks, identities are increasingly open, creation is more than ever a form of communication, and all of this suggests new readings of the human condition.

Just as neurons operate as nodes of the nervous system, so global society interacts in an analogous way. Sleepless and hyper-connected, the web never stops vibrating and calling to us. Its answers always constitute on-line thinking — a text that is written as it is being projected on all of us, a story that grows and ramifies infinitely like Borges' gardens and libraries. No one knows the shape or limits of this living labyrinth, but, from individuals to states, we all know that we are acting inside it as generators of energy and information flows and, in the best cases, as producers and transmitters of knowledge. In an unprecedented Copernican twist, we have shifted from the "human for himself" proposed by Sartre to the "human node" as defined by network theorists. And thus, just as a flow of information runs through our cells, so our social and cultural connections are part of a universal narrative of which we are an active part at all times. There is no longer a place for isolated stories in this agora where art, philosophy, literature and science are in constant dialogue, not only with themselves and by themselves, but also among each other and for everyone. Being a citizen today implies being part of a highly dynamic and changing system incessantly crossed by immense flows of energy, matter and information. Exploring our world has become an adventure again, for the profile of a neuronal texture as drawn by Cajal has grown into the paradigm of the Internet.

*banquete_ nodes and networks* is born of the theoretical and practical requirement to investigate the new conditions of "network society" and the space of flows that define the 21st century globalized world. In this context, the model of cultural production in force until now — based on a hegemonic center and unquestionable axes — gives way to a new structure of multiple nodes and changing, evolving networks. This structure is characterized by a constant flow of information as well as connection and dialogue in a network where every point is a node, an outlook, a story. In short, we are talking about a new, multi-centred and dynamic system of cultural production and diffusion in which ideas and concepts, like subjects, entities and institutions, are all agents and catalysts of an emerging process of social and cultural transformation.

This publication is structured in four parts, whose contents make up the nodes of a network not necessarily tied to a linear reading. These four threads emphasize the systemic and trans-disciplinary character of the proposal by taking advantage of one of the network's key characteristics: the fact that it is a pattern that operates regardless of scale. Thus, the first part, "Info_nano_bio_socio", shows how the network pattern connects and runs through different space-time scales and contexts, as set out in the essay, "Trapped in the network: nanoworld, life, society", written by researchers Carlos Briones, Susanna Manrubia and José Ángel Martín-Gago. Their reflections run from nanometric scales of life right up to social and cultural dimensions. Antonio Acín, Juan Ignacio Cirac and Maciej Lewenstein then contribute a description of the innovative field of "quantum communications", where they are researching the processes of "percolation" and "entanglement." Alfonso Valencia offers a "Research Proposal on co-evolution." The first chapter is related to the projects of Álvaro Castro, Pablo Armesto, Raquel Paricio and J. Manuel Moreno, José Manuel Berenguer and Laboratorio de Luz. It continues with the dialogue "Networks, the vital principle", co-written by Ángela Delgado and Diego Rasskin-Gutman, and Javier DeFelipe's essay, "Cajal and

Neuronal Circuits", which leads us through the works of Águeda Simó, Ricardo Iglesias, Daniel Canogar, Marina Núñez, Evru and Marcel·lí Antúnez.

The second part, "Info_socio_cogno", draws relations among the informational, cognitive, social and cultural dimensions that define the emerging paradigm of "network society". It begins with the essays, "Networks and owners of knowledge" by Ernesto García Camarero and "A walk through the realm of art and science today" by Capi Corrales. Pau Alsina takes on the question of "Culture in networks, network culture: emerging dynamics and economic policy." Pedro C. Marijuán refers to "The role of information networks in the evolution of social complexity", and Fernando Sáez Vacas deals with "Infotechnology: new social forms, noometamorphosis and noomorphosis." This is followed by a selection of works by the artists Marta de Gonzalo and Publio Pérez Prieto, Dora García, Concha Jerez and José Iges, Aetherbits, Francisco Ruiz de Infante and Eugenio Ampudia. The second part concludes with a selection of contents from the blog "Networks: forms of symbolic and social construction", which was carried out over the course of four months by Santiago Eraso, Jorge Luis Marzo, Arturo Rodríguez and Natxo Rodríguez; as well as the essays "The critical dimension of artistic practices in the web 2.0 system" by Juan Martín Prada, an extract from José Luis Brea's text, "The web generation: the power of 'us'" by Imma Tubella, "On the Internet (a few loose thoughts)", and "Networks of users and free knowledge" by Javier Echeverría. The artists and collectives linked to the close of this second part are Platoniq, Neokinok TV, Pedro Ortuño, Antoni Abad, Daniel García Andújar/Technologies to the People and Joan Leandre.

The third part, "Info_socio_urban", explores into the urban dimension as a context that catalyzes interactions among social, informational and cultural processes. It brings together and relates Vicente Guallart's *Sociópolis* project and Salvador Rueda's text, "Networks of urban sustainability: towards a model of a knowledge city" with José Antonio Millán's project, "(METAGRAPHS) TOTAL QUIDATION. Words, men and time" and texts and works by Hackitectura.net, Clara Boj and Diego Díaz, Escoitar and Influenza.

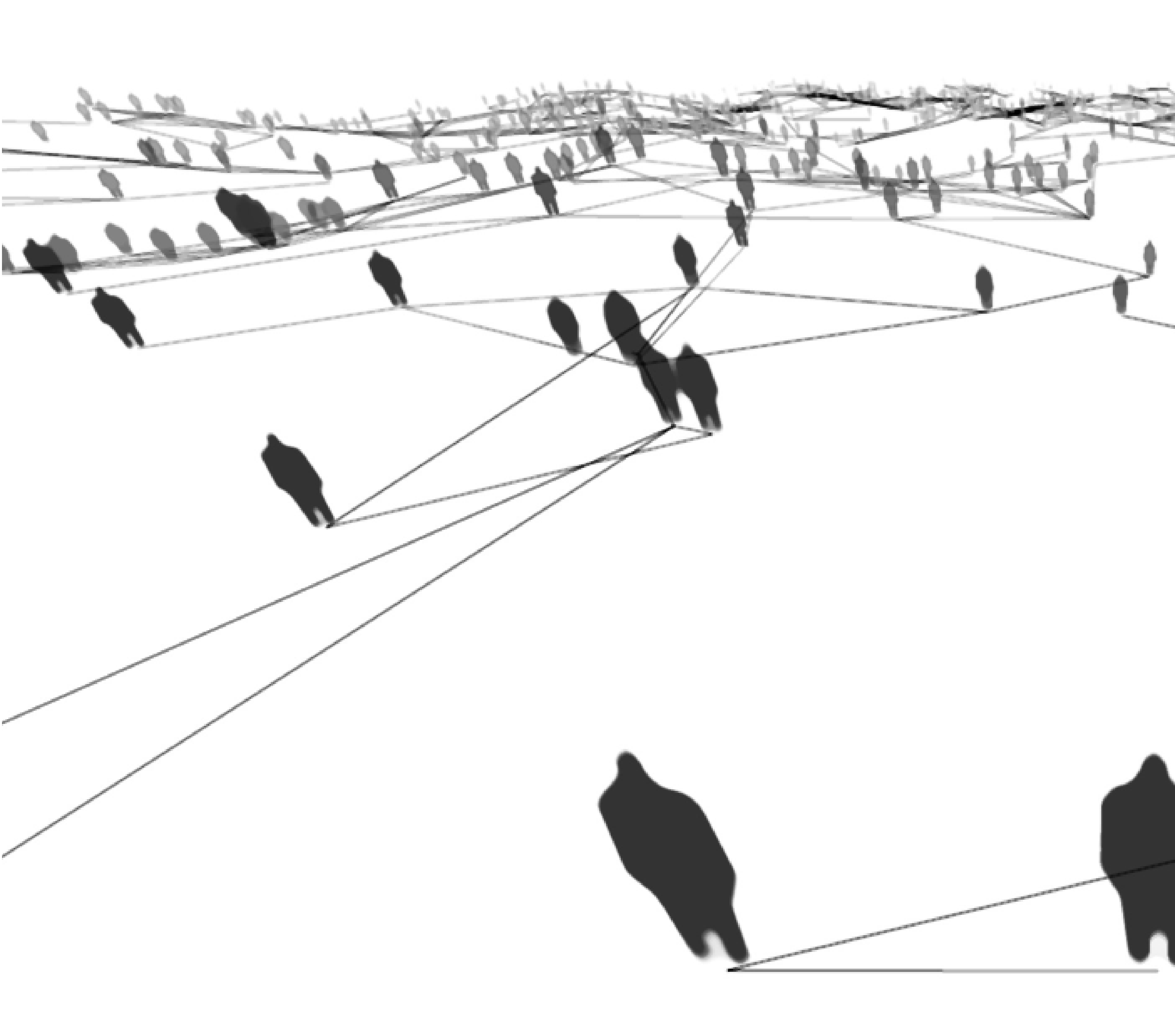
The fourth part, "Info_socio_eco", looks at the networks of ecosystems and planetary scales with which global change confronts us, as well as their socio-cultural, economic and ecological implications. Óscar Carpintero and José Manuel Naredo take on the question of "Financial markets and the creation of money in the cybersphere." Ramon Folch studies the relations between "science, networks and art: visual arts and ecology." José Manuel Montoya, Miguel Á. Rodríguez and Ricard Solé delve into "The architecture of nature: complexity and fragility in ecological networks." The section continues with a reflection by José María Baldasano on "Climate change. Sustainability in networks." Andreea Munteanu and Ricard Solé study "The large-scale organization of chemical reaction networks in astrophysics." The artists whose works explore similar concepts and contexts are Alfredo Colunga, Kònic Thtr, Daniel Canogar and Joan Fontcuberta.

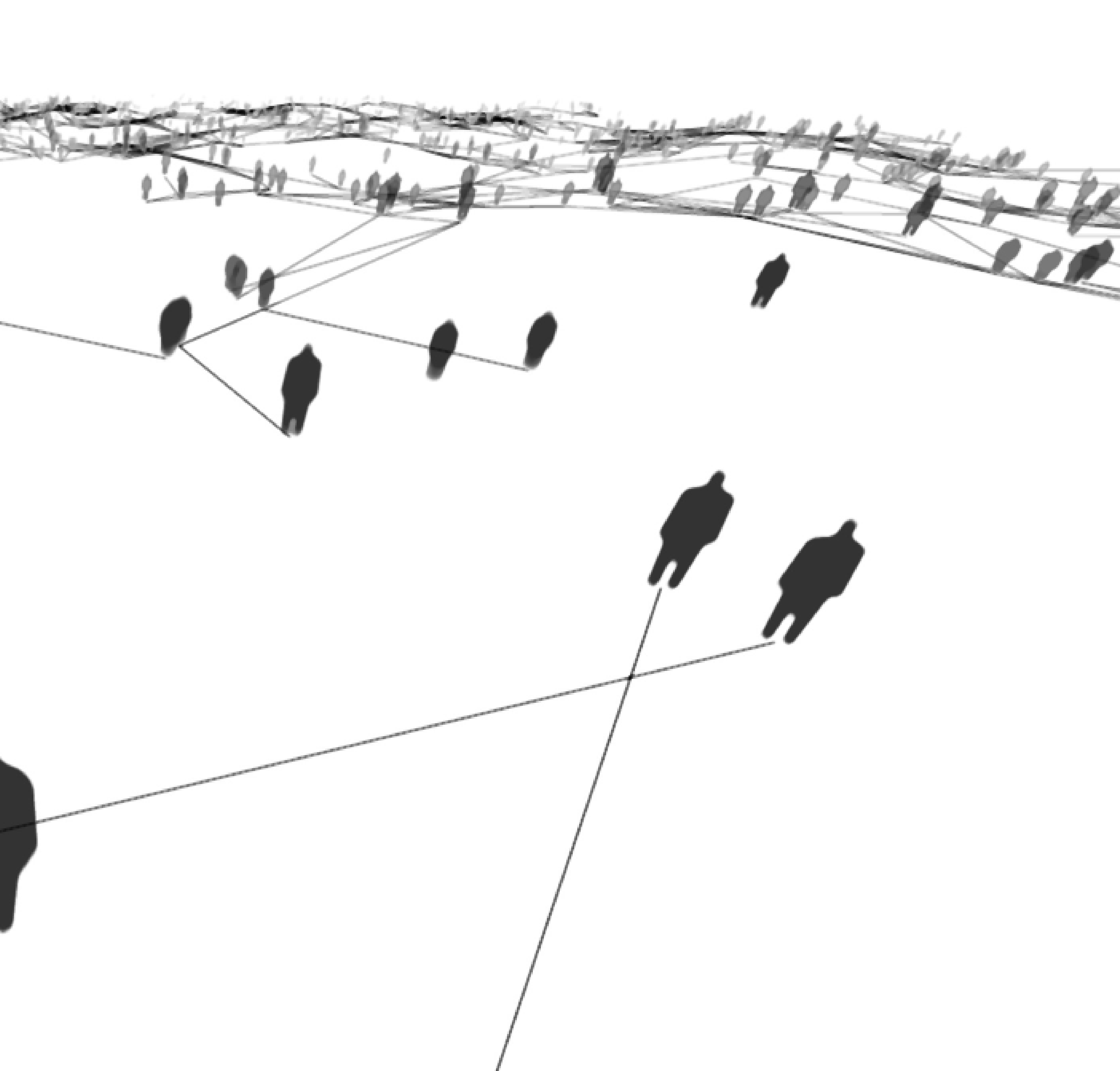
The book concludes with an interview titled "Internet. A new *imago mundi?*" led by Álvaro Bermejo, with answers from Juan Aranzadi, Agustín Fernández Mallo, Ramón Guardans, Vicente Verdú and Remedios Zafra.

Technological convergence favours the trans-disciplinary investigation of interactions among living and artificial systems for designing new devices that allow us to expand or improve cognitive and communicative capacities. The incorporation of the humanities and social sciences, and especially the current and most innovative artistic practices — their borders are increasing by blurred

because of their capacity to hybridize with other fields and disciplines — can play an important role in dynamizing these interactions and transversal creative processes. At the same time, emerging artistic practices can contribute a symbolic, communicative and socializing function, as well as critical and participative meanings and actions that are fundamental for collectively understanding and metabolizing the vertiginous processes of socio-cultural transformation in which we are inexorably involved.

In the contents of this project we find a growing correspondence among different fields and disciplines in methodology, tools, concepts, codes and languages. As it stands, in the new scenarios pertaining to the "society of information and knowledge", the traditional linear conception of the production and transfer of knowledge based on the science-technology-industry-society axis is transformed into a complex, non-linear network of trans-disciplinary relations. This network surpasses earlier frameworks and fosters permeability and communications among fields of knowledge and production. In sum, this publication, *banquete_nodes and networks,* is an effort to dynamize interaction among those techno-scientific fields, humanities and social sciences in order to help articulate a global viewpoint and the concomitant cooperative action, as mentioned here by José María Baldasano. This process is capable of overlapping a variety of different elements to form a single complex tissue extending in multiple directions. The concept of "network" offers us an excellent leitmotif for contemplating and connecting scales and contexts — a network that can constitute a new way of interpreting and constructing reality.





# Nodes and networks

Karin Ohlenschläger

The concept of a global network that connects and unites us resonates down the ages as one of the most ancient aspirations of the human race. If we consider the Latin verb *religare*, meaning to bind or to unite, the religious connotation is clearly evident. In the industrial era, it is no longer the gods but their earthly representatives who are instrumental in fashioning a world closely linked by transport and communications networks, and through scientific and technological progress.

In earlier times, these networks were created by opening up routes to travel by land or to sail along rivers and across the seas. By the 19$^{th}$ century, thousands of kilometres of cables crossed the Atlantic, railway lines scored the landscape, and road networks joined up towns and cities. Today we continue to use these networks, but we have added satellite links, fibre optics and all kinds of wireless connections that pass invisibly through the air in every direction.

However, even in this era of information and telecommunication technologies, we are still living with the paradox of an interconnected, virtual world with no apparent boundaries and a physical world in which barriers of concrete and barbed wire are being raised, along with other means of confinement and digital control by satellite. There are thousands of miles of borders between North and South America, between southern Europe and North Africa, and between Israelis and Arabs, among others. Thus, at the same time as we champion free access and flows of information, goods and finance, we are strengthening mechanisms of control, censorship and exclusion. Not for nothing do the statistics show that, in this era of real time connections, 20% of the world population control, consume and squander 85% of our planetary resources. And this asymmetry has not diminished: it is actually increasing. Among the conclusions of the World Summit on the Information Society[1] comes a warning of the growing divide between the info-rich and the info-poor. Only 20.89% of the world population has access to the Internet, whilst the majority slip through the holes in that network.

It is clear that, behind the idea of union or unity, the familiar cravings for power, expansion and appropriation of the Other still exist: the age-old struggle for control and domination continues by means of increasingly sophisticated methods and techniques.

If we analyse the concept of "unity" and its implications beyond the obvious appeal of its positive meaning, we shall see that it rests on a conceptual or material core of absolute, centripetal power. In any system of coexistence, unity involves correspondence and conformity. It means that things are incorporated and integrated to form a body that cannot be disunited without the alteration or destruction of its essence. Unity is therefore closed: its internal structure tends to be stable, self-referential and non-relational.

In *banquete_nodes and networks*, we begin by assuming that the world is not united, and nor should it be, under totalitarian techno-economic directives of the market or the ideology of the *pensée unique* (or "single thought"). In the current political, economic, social and cultural crisis of the system, the concept of unity or union sometimes reappears and is even confused — delib-

erately or otherwise — with the new potential of connectivity. For this reason, for this project we decided that we would explore the many different modalities of networks of interconnected relationships, and this exhibition and book are the result.

Connectivity is, above all, plural and relational. It presupposes an aggregate of intermittently interwoven singularities in movement and, therefore, only temporarily united. Within an interconnected system, unity becomes a relative, temporary, non-absolute value. Connectivity is a quality inherent to a system with the capacity for development and growth in diversity. It not only describes a state, it is related to action over time whose duration can be very variable. This process occurs in open systems — such as living systems — that are, by definition, changing and unstable.

Connectivity is both a conceptual and a functional tool which enables us to relate very large space-time dimensions to very small ones, helping us to understand the form and function of life. As Diego Rasskin-Gutman and Ángela Delgado explain in this publication, "we are built, life is built, organized and selected from the rhythms of the system's relationships [...] Life as a continuum is a process whose motion began thousands of millions of years ago and it continues to move onward. And all of it thanks to networks."[2]

The idea of connectivity — understood as a basic requirement for any process of information exchange — and the concept of an open, evolutionary network were first articulated as the structural basis for neuronal communication at the end of the 19th century. Until then, it had been believed that neuronal networks constituted closed circuits, units of command directed from a central point by intelligence and reason. However, the neuronal theory developed by the histologist and neuroscientist Santiago Ramón y Cajal (1852-1934) challenged the previously accepted idea of unity and permanence.[3] It questioned the physical continuity between neurons and went on to postulate a system consistent with separate units, interconnected only by means of synaptic clefts.

In accordance with Santiago Ramón y Cajal's thesis, neuronal networks are conceived as open, changing systems. In relation to the intensity of the stimulus received, the connections between cells can be temporary or permanent. Neuronal circuits can grow in one direction and atrophy in another. They are able to produce new ramifications and generate other connections. Their behaviour is an expression of genetic and epigenetic activity, of the interaction of the hormonal and metabolic systems, and of flows of internal and external signals, stimuli and movements.

The connections between cells form specific circuits, each one communicating with certain cells and not with others. A neuron can transmit information to many other cells located in different areas of the brain. In turn, it also receives and processes information from them. In short, the function of the components of a nerve cell is the transmission of signals. However, within the neuronal network, what makes us think, feel or act in a particular way at any given moment are not the cells themselves but the specific connections and relationships that are established between them.[4]

There is no doubt that the ability to establish new connections and relationships between things is fundamental for the evolution of any cognitive system. If life itself is a process of cognition or, in other words, of learning and co-evolution, then so are culture and art. The reticular structure of the connections is specific to each area, each experience and each field of knowledge. The nodes that make up any network are organizationally closed, just like cells, bodies, communities or cities. But, from the functional point of view, they are open in order to be able to relate to one

another, to sustain themselves by means of exchanges of material, energy and information, to grow and to change.

Networks surround us, pass through us, are part of us, entrap us and compromise us; they also enable us to connect and evolve in experience and knowledge by means of their multiple circuits. Each individual is a node and part of a network of relations that cascades over many space-time scales: from the solar system[5] to the processes taking place within a living cell.[6] The transport and communications networks created through human activity criss-cross the earth; technological devices are launched in search of links with other planets and solar systems; networks connect the human body, influence neuronal circuits, invigorate interconnected minds and modulate quantum communications between nanometric particles.[7] The boundaries between biological and technological life have now become blurred by the advent of nanotechnology and the convergence with microelectronics. This means that networks extend outwards from within ourselves to encompass the entire range of human activity, overcoming barriers of space and time.[8]

In the same way that neuronal circuits are constantly changing — as Cajal pointed out — so are the organizational networks between atoms and molecules,[9] as well as networks of relations between people, communities and cultures.[10] The network model, present on every scale and in every sphere of life, has all its parts arranged in an open, dynamic, self-organising, evolutionary system. Consequently, we can observe the same pattern in water molecules as in ecological networks, and even in the structure and dynamics of the World Wide Web.

It is worth noting that the neurosciences have not found a central storage point for information or memory. This is because there is no closed, autonomous control centre in the brain. For this reason, the concept of an evenly distributed and decentralized information system was as revelational at the start of modern neuroscience as it is today in addressing the challenges of what we call the "network society".

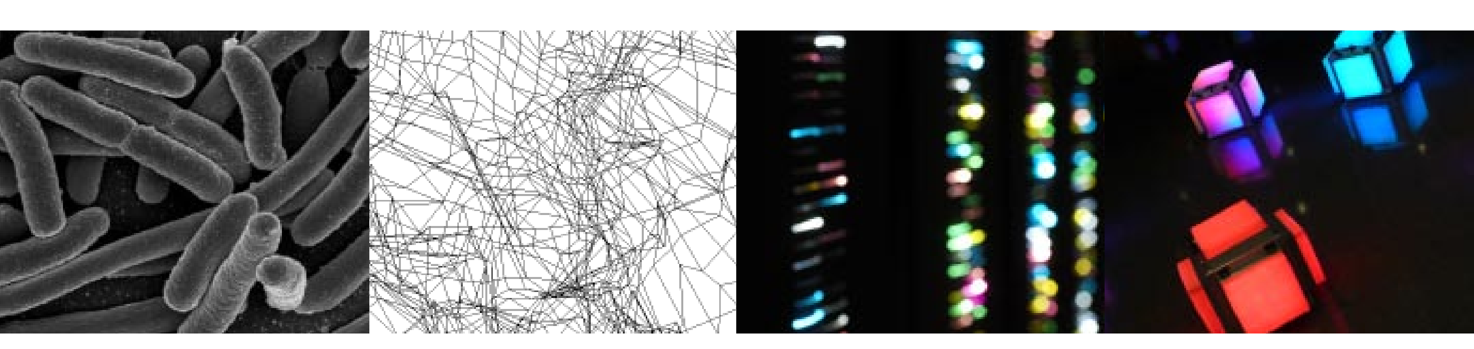
Analogous to the way that neurons operate as nodes of the nervous system, cities in the "network society" have become communicational nodes. In both cases, structures are created whose main value is the connection and communication between their elements. In both cases, the quality that defines them and keeps them operative is not, strictly speaking, their physical structure but their connective capacity to receive (inputs), transmit (outputs) and process information (outcomes). At the present rate, we are on the point of creating an interconnected, dynamic, collective mind — if we have not already done so. It would be a mind whose structure is visible in the urban configuration of the "network society", and its function, in the constant flow of information: a mind in the form of an *exocerebral network*.[11] Connectivity, *that personalised form of collectivity,*[12] thus emerges as the historical evolution of our social organisation through electronic means, by extending our bodies and our relationships. Analogue and, later, digital devices have merely redirected the organizational form of socety towards the pattern that runs through all aspects of life: the network.

Early in our current communications era, which began with radio and progressed to television, the production system was centrally organized with one-way distribution channels from the few to the many by means of broadcasting. Since the end of the 20th century, we have been able to build one-to-one or P2P relationship networks by means of mobile telephony and the Internet on a space-time scale — and over distances and at speeds — unprecedented in the history of humanity. In his extensive investigation and analysis of the information era, Manuel Castells has concluded that

networks "[...] constitute the new social morphology of our societies, and the spread of their kind of links substantially modifies the operation and results of production processes, experience, power and culture."[13]

Given that technological systems are produced socially and social production is linked to culture, our current digital era is increasingly defined by a renewed network of trans-disciplinary interactions between the arts and the sciences, and between the technologies and their social uses.

The construction and perception of reality is no longer the preserve of centres or hubs of knowledge and hegemonic power, as Ernesto García Camarero explains in *Networks and owners of knowledge.*[14] As a result of the current information and telecommunications technologies, other structures and new connections and communication spaces have emerged. New relationships between experiences and knowledge nourish a large variety of emerging collective dynamics. In fact, any citizen can now participate in the production and circulation of information and contribute to the generation of knowledge today. The user of a mobile phone, a digital camera, a computer and/or Internet connection is not only the receiver but also the producer and trans-



mitter of signals, narratives, images and sounds. Present-day art in the sphere of digital culture lends itself to all these new constellations of production and distribution. As the members of the Fundación Rodríguez have stated, "the commitment of artists to a free, universal culture is one of the first steps to flexibilize a whole system of complicated hierarchies that govern the art world, and in which it is essential to defend creativity by sharing it."[15]

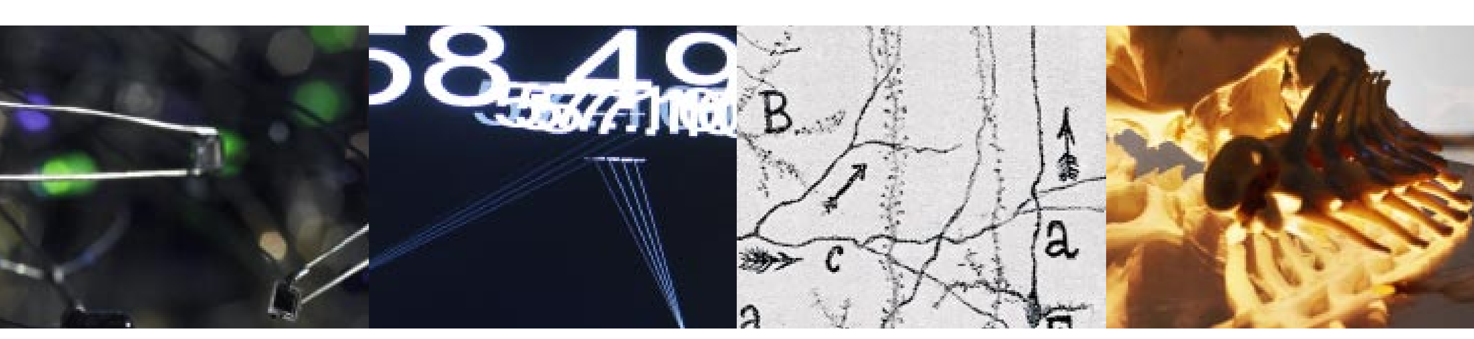
This commitment to structural change in the world of Spanish art can be traced as far back as the new artistic attitudes of the early 1970s.[16] Experiences that were closely linked to the political and social movements of the imminent political transition. Artistic methods that advocated the creation of new spaces for, and dynamics of, production and distribution. From that time on, an enormous variety of networks of relations began to emerge.

An example of these would include the dialogue begun in the late 1960s (1968-1973) between art, science and technology at the *Centro de Cálculo* of the University of Madrid,[17] while seminars and research into different codes and languages, and patterns of relations and behaviour in the spheres of visual, architectural and linguistic expression, provided a plentiful source of ideas and methods that, decades later, would evolve into diverse areas of digital culture.

In the 1970s, while some experimented with binary code, others began to explore the world of media communication, challenging the hierarchical structures of the media, and demanding their democratization and socialization through independent audiovisual production. *Cadaqués Canal Local* (1974) and *Distrito Uno* (1976) by Antoni Muntadas,[18] and the experiments in community video by the collective Video Nou/Servei de Vídeo Comunitari (1977-1983)[19] led to the first networks of communication between artists, local groups and neighbourhood associations for the purpose of creating new methods of production, and environments for self-managed communication independent of the only two state television channels in existence at that time.

The 1980s were marked by the transition from analogue production to the early means of digital production. Video and the first personal computer systems allowed a new trans-disciplinary dialogue between the fine, visual, sound and scenic arts. This new form of creation was exemplified by the emblematic *Espacio "P"* (1981-1997) in Madrid,[20] one of the few independent venues run by artists at that time.

Coinciding with the political and economic crisis and the drastic cuts in institutional spending in Spain in the 1990s, similar initiatives were organized by the artists themselves throughout the




country. In the various encounters of contemporary art, *Red Arte,*[21] organized between 1994 and 1997, there were some one hundred independent collectives and initiatives represented from all over the country. Their discussions and proposals dealing with the structural foundation and functional dynamics of the emerging cultural networks were aimed at advancing a new dynamic for dialogue and collaboration between an increasingly heterogeneous mix of proposals and formats.

In the same decade, artists were frequently becoming the creators of virtual communication spaces. No longer were they constructing objects but rather they were involved in new, temporary, participative structures and channels for production and distribution. Internet projects such as *The File Room* by Antoni Muntadas (1994), *Conexión Madrid* (1996) and *Peninsulares* (1996) by Maite Cajaraville, or the platform *Irational.org* which led to *Technologies to the People* (1996), to give just a few examples, were the forerunners of the idea of on-line social and cultural networks, as well as the creation of open, self-managed files on the web, years before the launch of MySpace, Facebook or Wikipedia.

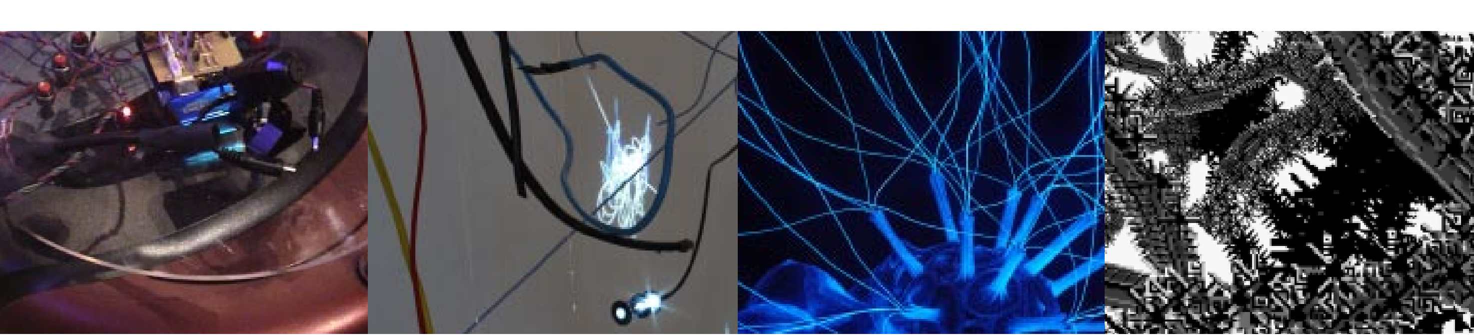
With the current information and telecommunications technologies, these pioneering initiatives have evolved towards new structures and spheres in the public domain that are expressed as

much *on* screens as *between* screens. In fact, in this decade, a vast number of new nodes and networks have been set up between artists, activists and citizens; or between architects, biologists, engineers and programmers, weaving temporary networks of very different kinds and sizes.

The works on show in this exhibition of digital art and culture in Spain analyse networks, question old links and build new ones. They offer and experiment with new ways of thinking, feeling and behaving at both an individual and a collective level. Above all, they create and share new tools for visualizing, modulating and participating in the construction of reality.

A large number of the projects are the result of research and dialogue among widely differing fields of experience and knowledge. Their proposals take us from bioinformatics to neuroscience and from sociology to urban planning, spanning the information sciences, economics and ecology.

*Banquete_nodes and networks* brings together over thirty interactive, digital art projects. They include photographic works, videos, virtual reality installations, artificial life robotic performances and net.art participative projects offering a broad overview that ranges from networks of molecular interactions to the global dynamics that arise from new relationships between people, communities and cultures.



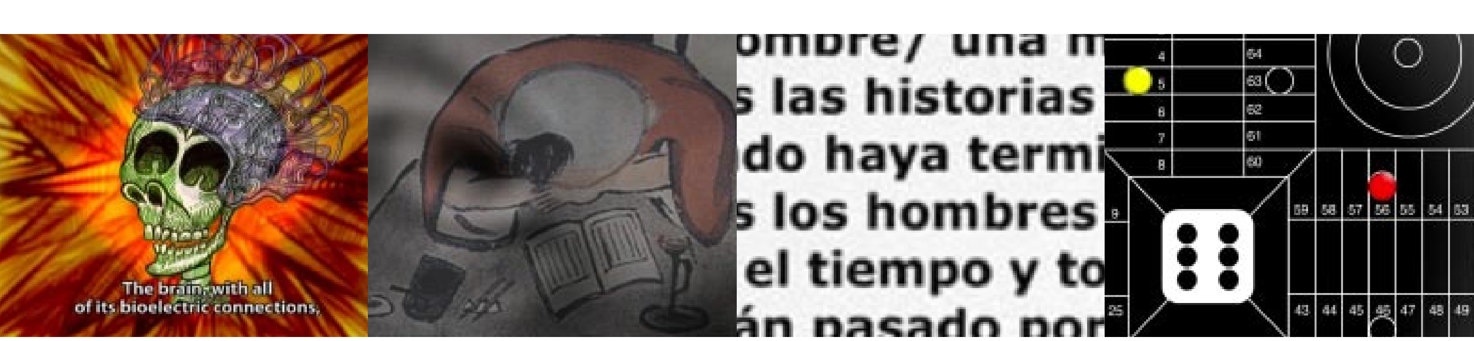
The projects on display in the exhibition *banquete_nodes and networks* explore, visualize or generate networks of relationships at the boundaries between art, science, technology and society; between physical and digital spaces; between local communities and global information flows; and between biological dynamics and technological connections.

As we explained in detail in the first edition of *banquete_metabolism and communication*[22], the networks of codes and languages that govern the world of information and telecommunications are not exclusive to the current techno-scientific sphere. Our biosphere is also an *infosphere* made up of a network of protocols, biochemical languages and electronic impulses. The introduction of art into the structures and processes of cellular networks significantly broadens the art-life discourse towards the microspheres of nanometric cellular nodes and networks, on the one hand, and towards the hybrid macro-environments of the body-machine interface, on the other. The interactive works and installations of Eugenio Ampudia, Marcel·lí Antúnez, Pablo Armesto, José Manuel Berenguer, Daniel Canogar, Álvaro Castro, Ricardo Iglesias, Laboratorio de Luz, Marina Núñez, and Raquel Paricio and J. Manuel Moreno address new modalities in the conception, perception and interaction between living systems and technological ones.

The project *Vacuum Virtual Machine* by the architect **Álvaro Castro** deals with complex systems. He has created a programme able to develop codes by which to modify itself and evolve. Using artificial life graphics software, the author visualizes the changing reticular self-organization of atoms and molecules. His project presents a network in visual form as the evolving, dynamic and structural basis of life.

The work *Sequences 24* by **Pablo Armesto** explores the combinatory relations of chromosomes on luminous screens woven from fibre optics. It refers to the as yet undeciphered relations of the code of life. Genes are not independent units either, as many of them superimpose and interact in a network, sharing information.

The research project *POEtic-Cubes* by **Raquel Paricio** and **J. Manuel Moreno** is also inspired by cellular communication networks, represented by nine luminous robotic cubes that behave as a single artificial organism. Each robotic cell changes its behaviour and relations by a process of interaction among all the parts of the system — including the audience present during the performance — that animates a network of communication and co-evolution connecting robots and humans.




With the interactive installation *Luci. With No Name and No Memory*, **José Manuel Berenguer** invites us to explore a network of interactions between light and sound inspired by the behaviour of fireflies. By means of different analogue and digital devices, he show us the way in which the sounds emitted by the fireflies are synchronized without any centralized coordinating mechanism.

*Light Modulator 3.0*, by the research group **Laboratorio de Luz**, turns an empty room into a space for interaction and random, evolutional communication. In this environment, the exhibition visitor initiates, explores and experiences the relationship light-space-time/reflection-shadow-movement, in order to generate new sound and space-time relationships.

The communication links between users and machines take on a disturbing form in *José, an Autistic robot* by **Ricardo Iglesias**. This project forms part of his series of investigations into *Evolutional Machines*. In this case, he turns a meek robotic vacuum-cleaner into a machine animated by dysfunctional behaviour and overcome by fear and autism. Interaction with this maladjusted robot is an unusual experience that questions our expectations of the obedient machines which we handle every day.

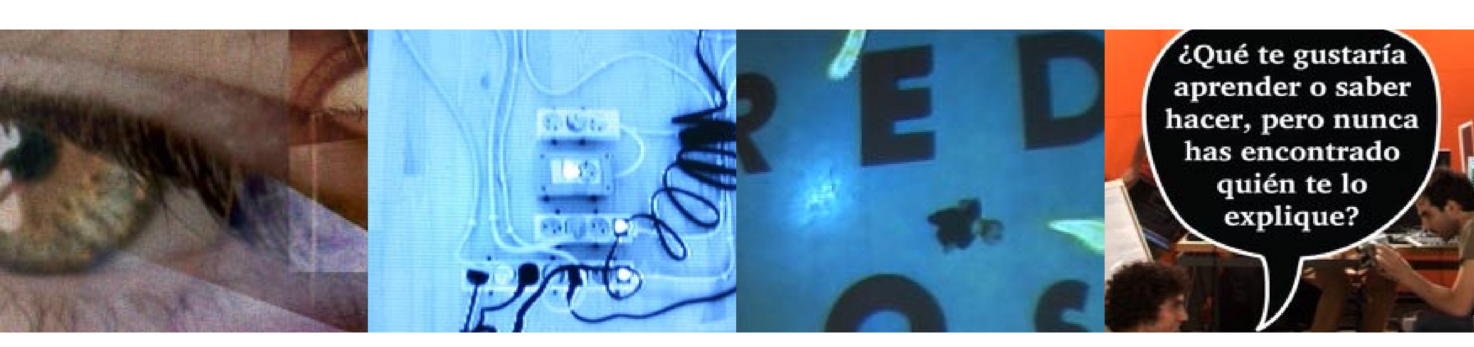
*Tangle* is a huge spider's web of electrical wiring from telephones and computers, and other waste cables from obsolescent communication networks. In describing the installation, **Daniel**

**Canogar** says that, "*Tangle* is, above all, a reflection on how technologies create complex emotional connections that unite as well as confine the contemporary being."

According to the neurosciences, the process of continuous learning and interaction with our environment can modify neuronal network connections and vice-versa. In her interactive installation *Reflecting JCC. Brain Research II*, **Águeda Simó** invites us to interact with the mental map of JCC and explore the relationships between perception, thought and behaviour of an individual whose reasoning is altered by their emotional state.

**Evru** offers us a playful and intuitive system of communication for connecting minds called *Tecura 4.0.* In this net.art project, linked up with a full programme of workshops and performances, the artist turns his own visual and sound language into an open source system that he shares with Internet users.

"Network society" is characterized as much by the new dynamic spaces of on-line communication and cooperation as it is by the new systems of surveillance and control of everyone by everyone. The video-installation *Queen*, by **Francisco Ruiz de Infante,** provides some disturbing reflections on neuronal networks and spaces connected via delocalized, omnipresent control systems, but with restricted access.




The man-machine relationship forms the basis of the work by **Marcel·lí Antúnez** called *Protomembrane.* It is an interactive lesson of sound and vision on *systemplaywriting* — literally, playwriting for computational systems — that he uses to weave a narrative full of fables about the interconnected, digital being.

In her installation *Untitled (science fiction)*, parabolic antennas, satellites and other devices of the global communications networks give mobility to the bodies floating in space with which **Marina Núñez** refers to the contemporary myth of the *cyborg*. This half-man half-machine is a ubiquitous, weightless, "telepresent", digital being with heightened perceptions and abilities. In another work of the same series, as well as in one of her most recent videos entitled *Twilight*, she takes a critical look at the nature of the biotechnological being.

In one of the mural photographs in the series *Other Geologies* by **Daniel Canogar**, several human bodies appear as half-buried rubbish in an impenetrable jumble of the debris of wires and computer parts.

Across from this wasteland, we find *Credulous*, an interactive installation by **Eugenio Ampudia** in which users discover other scales of existence and thereby experience a certain perceptive

disorientation on seeing themselves projected as minute beings surrounded by giant amoebae that react to their presence in real time.

The creation of new techniques and participative tools as catalysts for processes of self-organization and the production and distribution of experience and knowledge are proposed by Antoni Abad and collectives like Platoniq or Neokinok TV. The ideological, conceptual and functional relationships between education, creativity and life form the basis of the audivisual project by Marta de Gonzalo and Publio Pérez Prieto.

In order to foment the self-organization of new social links, **Antoni Abad** has developed his artistic projects under the common denominator of *zexe.net.* It is based on an operating system that comprises mobile telephony and Internet and is designed to serve marginalized populations in urban areas. Three of his recent experiences, *Canal*MOTOBOY*, *Barcelona*ACCESSIBLE* and *Geneve*ACCESSIBLE*, undertaken with motorcyclists in Sao Paolo and the disabled in Barcelona and Geneva, are examples of how it is possible to increase the visibility, self-management and self-determination of urban groups through current artistic techniques. In this case, the artist did not take part in the production of the images but




provided access to the tools and reticular architectures of communication to specific social groups.

Direct participation in the collective indexation of all kinds of knowledge — from a recipe to a software application or a course in relaxation — is what is proposed by the collective **Platoniq** in *Bank of Common Knowledge (BCC)*. It consists of a platform for the exchange of knowledge and experiences, as well as for connecting everyday oral culture with on-line digital communication networks that lie outside the criteria of commercial speculation. *BCC* is also a laboratory in which to experiment with new methods of production, learning and citizen participation.

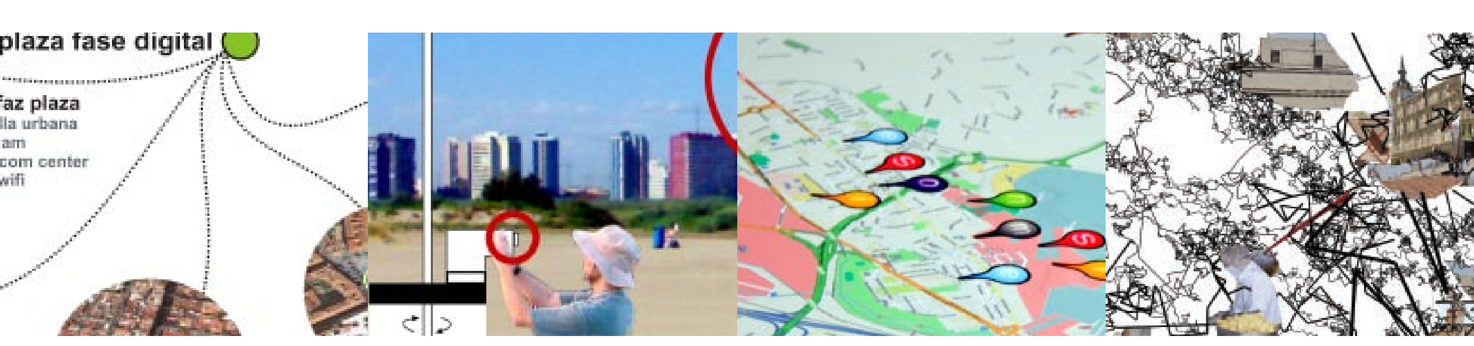
The collective **Neokinok TV** also works on creating educational tools and methods. It generates communication networks and links aimed at fostering the self-determination of those citizens who are most disadvantaged by the growing digital divide. One of their most recent projects, called *TV-Lata*, joins art to education to create an experimental on-line television channel with a group of young people from the neighbourhood of Los Alagados, an outer suburb of Salvador de Bahía in Brazil.

*The Intention* is another of the artistic projects that combine art and education. In their video-installation, workshops and publications, **Marta de Gonzalo** and **Publio Pérez Prieto** offer a

critical review of educational principles that are increasingly tied to a discourse of efficiency, competitiveness and profitability. As an alternative, they present an audiovisual education programme that attempts to restructure the ideological, conceptual and functional relations between education, cooperation, creativity and life.

The interactions emerging between physical and digital spaces, territorial networks, local environments, and their interdependence with global dynamics are investigated and visualized in different ways by the collectives and artists Hackitectura, Escoitar, Influenza, Kònic Thtr, Clara Boj and Diego Díaz, and Pedro Ortuño.

The group **Hackitectura** presents two works that connect the virtual world of networks with the physical space of real places. Their urban architectural project *Wikiplaza* transforms an enclosed space of bricks and concrete into a place that is open and permeable to communication flows. Their action videos *Emerging Geographies* portray a successful experiment in coexistence and collaboration between artists, programmers of free software and the inhabitants of a rural part of Extremadura, in a temporary laboratory set up outside a decommissioned nuclear power station.




In the production workshop *Air, Sound, Power*, the city becomes a source of information and raw material for the creation of soundscapes for the collective **Escoitar** in the weeks leading up to the inauguration of the exhibition at LABoral and at ZKM. The group invited the inhabitants of Gijón and Karlsruhe, to explore their urban environs and to put together a shared interactive, participative sound map of the city, which would be accessible to both exhibition visitors and internauts.

In *Observatory*, **Clara Boj** and **Diego Díaz** use augmented reality devices to visualise the nodes of free access to wi-fi networks in the city. The close links between urban spaces and these virtual connections for communication also provide the conceptual framework for the interactive installation entitled *Madrid Mousaic* by the collective **Influenza.** Their work is a living, changing mosaic that portrays a variety of social environments in Madrid and is sensitive to the sound produced by visitors to the exhibition.

Incessant migratory flows and their influence on individual and collective identities in an increasingly interconnected and interdependent world are the theme of the interactive installation *mur.muros/Dystopia #2* by the collective **Kònic Thtr**.

The project *White and Black* by **Pedro Ortuño** takes a close look at the lives of those in a rural environment whose isolation, poverty, precarious employment and existential uncertainty is growing as fast as the connectivity and wealth of others.

Social and informational networks on the Internet are the subject of works by Aetherbits, Dora García, Concha Jerez and José Iges, Alfredo Colunga and Joan Fontcuberta. Some of them review the issues of authorship, originality and veracity. Others examine new links between current artistic practices and their relationship to citizens, microproducers and distributors through the World Wide Web. Projects by Joan Leandre, and Daniel García Andújar and Technologies to the People deal with open-source network culture.

*All the Stories* is a pioneering work of micro-narratives in the form of a blog, conceived by **Dora García** as a work-in-progress. Since 2001, this project has continued to evolve with the publication of short stories that talk about anonymous men and women, about experiences, feelings and events woven together by dates and key words on the Net of networks.

In *Terre di Nessuno: Quicksand*, **Concha Jerez** and **José Iges** confront the user of their interactive installation with the uncertainties, tensions and conflicts that arise on a virtual Parcheesi board, on which some squares sink the player into the shifting sands of global information networks.



By means of images tracked by an Internet search engine, the *GoogleGrams Ozone* and *Prestige* by **Joan Fontcuberta** visualize the new iconographies of an increasingly globalized, interconnected and interdependent collective memory, including both its successes and its failures.

The Internet project *The E Day for Energy* by **Alfredo Colunga** invites us to reflect individually and act collectively in support of new energy sources for a planet with limited resources.

*Social Synthesizer_Prototype*, by the collective **Aetherbits**, is a polyphonic, audiovisual synthesizer that processes a flow of signals, both images generated in real time by the users of the social network Flickr and sounds produced by Skype users. As its creators explain, “this interactive project consists of a system of managing audiovisual contents that allows the public to explore the global repository of social memory that is the Internet.”

The political, social, economic and cultural implications of freely distributed software, on the one hand, and centralized proprietary software, on the other, form part of two scenarios and two narratives that make up the complete installation *X-Devian*, *The New Technologies to the People System* by **Daniel García Andújar**. This project plunges into the cultural controversy over software, which some see as a product and others as an open, participative process.

In his installation *NostalG2 // L'AGE D'OR NFO.EXE*, **Joan Leandre** offers a tribute to the seminal rituals and protocols of digital contamination: a global dataflow that no node can bring to a halt; an ambivalent network, both creative and destructive.

This overview of the exhibition *banquete_nodes and networks* seeks to encourage visitors to experience the emerging connections between living and technological systems. These are connections that are present not only in the spheres of science and art and in our everyday surroundings but also in the continuum of discontinuous — open and variable — connections that make up life and the relationships between its parts. This model, that is shared by the microscopic and the macroscopic, the biological, the social and the cultural, is what is tackled in different ways by all the participants in this exhibition. They have developed projects that show the intense and fertile synergy that is being created on the boundaries between art, science, technology and society in the digital culture of today.

The thesis underlying the *banquete* project carries an implicit call for thought and action. In any historical — or post-historical (according to some conservative thinkers) — moment of intense change, where the metamorphoses of human life in all its facets are taking place at exponential speed, it is necessary to retain some perspective. Our overview merely attempts to shed some light on the dynamics in which we are all caught up, although, of course, all knowledge carries within it the potential for change. Perhaps an understanding — however slight — of the nature of open and evolving systems in the "network society" can help us to take advantage of the opportunities to map out our future present. A network is based on the capacity of its nodes to create their own functional configuration in a cooperative way. If determinism and power centres can be kept at bay we are all potential nodes capable of reconfiguring the map of our own relationships in the "network society".

**Notes**

**1** According to data from 2007, published on the website of the World Observatory of Telecommunications, the sponsor, together with the United Nations Organization, of the Tunis Summit. <http://www.itu.int/wsis/documents/index2-es.html> (accessed January 30, 2009).

**2** Rasskin-Gutman, Diego, Delgado, Ángela: "Networks, the vital principle", p. 78.

**3** DeFelipe, Javier: "Cajal and Neural Circuits", p. 87.

**4** Kandel, Eric R. (2007): *En busca de la memoria. El nacimiento de una nueva ciencia de la mente*, Katz Barpal, Buenos Aires, pp. 84-93.

**5** Montoya, José M., Rodríguez, Miguel Á., Solé, Ricard: "The architecture of nature: complexity and fragility in ecological networks", pp. 297-305.

**6** Briones, Carlos, Manrubia, Susanna C., Martín-Gago, José Ángel: "Trapped in the network: Nanoworld, Life, Society", pp. 49-55.

**7** Acín, Antonio, Lewenstein, Maciej, Cirac, Juan Ignacio: "Quantum Communication: Entanglement and Percolation", pp. 56-57.

**8** Castells, Manuel (2006): "Informacionalismo, Redes y Sociedad red",in *La Sociedad Red: una visión global*, p. 31.

**9** Briones, Carlos, Manrubia, Susanna C.and Martín-Gago, José Angel: "Trapped...", pp. 49-52.

**10** *Ibid.*, pp. 55-57.

**11** Bartra, Roger (2006): *Antropología del cerebro. La conciencia y los sistemas simbólicos*, Barcelona.

**12** Kerckhove, Derrick de (1999): *La piel de la cultura. Investigando la realidad electrónica*, Barcelona, p. 19.

**13** Castells, Manuel (2002): *La era de la información*, Vol.1, La sociedad red, Madrid, p. 549.

**14** García Camarero, Ernesto: "Networks and owners of knowledge", pp. 119-130.

**15** Fundación Rodríguez (2007): *Estructura-redes-colectivos (un segmento conector)*, Vic, QO7, 2007.

**16** Marchán Fiz, Simón (1986): *Del arte objetual al arte del concepto*, Akal, Madrid, pp. 153-159.

**17** García Camarero, Ernesto: <http://elgranerocomun.net/rubrique29.html> (accessed January 30, 2009).

**18** *Proyectos-Muntadas-Projects*, catalogue Fundación Telefónica, Madrid, 1998.

**19** Ameller, Carles, Martín, Leo (2006): "Televisión creates an impression of humanisation", in *La televisión no lo filma, Zemos 98*, Sevilla, pp. 250-257.

**20** <http://www.sitioweb.com/sitio3/p/espacio/> (accessed January 30, 2009).

**21** *Encuentros de Arte Actual, Red Arte y Colectivos Independientes en el Estado Español*, Transforma (ed.), Vitoria-Gasteiz, 1997.

**22** Ohlenschläger, Karin and Luis Rico, *banquete_metabolismo y comunicación*, in the nomonym catalogue, pp. 21-57 (at press).

# Symbiogenesis, innovation and cultural networks. Towards an ecophysiological view of the generation and transfer of knowledge

Luis Rico

> Being, doing and knowing, in the domain of life, are, in their origin, undifferentiated, and when they become differentiated they continue to be inseparable. **Edgar Morín**

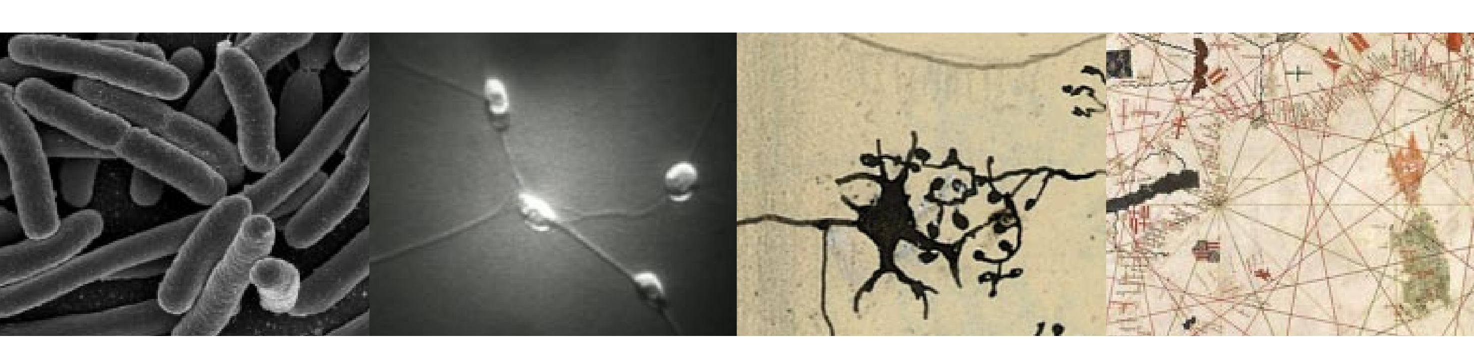
Symbiogenesis is one of the processes that underlies the generation of evolutionary innovation. It deals with long term symbioses (from Greek, *symbioun*, "live together") between organisms of different species that may lead to a new integrated entity that includes the formerly independent components by means of fusion, followed in some cases by the acquisition of genomes. This article considers some of the ideas that inspired the origin and evolution of the *banquete* project since the early 1990s. It explores the potential of symbiogenetic ideas that came to light in the field of biology at the start of the 20th century with two aims: 1) to interpret the emerging dynamics and structures of knowledge management and 2) to devise a framework for actions that promote the interaction of diverse scientific and social fields, disciplines and methodologies through the use of current infotechnologies. A century after these visionary ideas appeared and were ignored or rejected for decades, they are gaining new life as models for cultural innovation analogues that respond to the needs of the *web society* in the age of global change: the exploration of new sustainable ways of interpreting and being in the world that are able to reconnect human societies, the technosphere and ecosystems.

## Movement

When we read these sentences, the complex network of electrochemical interactions among neurons that Ramón y Cajal revealed to us is activated. Through respiration, oxygen reaches the brain and enables glucose and other molecules obtained from food to be transformed into metabolic products. Among these, the water and carbon dioxide created by one of these metabolic processes circulate through an intricate web of blood vessels, while others enable the neural membrane to respond to variations in the concentration of sodium and calcium ions on either side, to modify their potential and to trigger a nerve impulse. The spread of these movements along complex neural networks is thought to lead to the emergence of mental constructs: symbols, images, concepts and ideas. "Life and thought are integrated into the same flow of material, energy and information transformation. Thinking and being are different aspects of the same physical organization and its actions" (Margulis, Sagan, 1997).[1] The evolutionary biologist Lynn Margulis and the neurophysiologist Rodolfo Llinás among others, state that thought is the internalization of movement. Thinking is the movement of mental objects. Its evolutionary origin can be linked to cell motility. It theoretically derives, in other words, from those first protist[2] movements produced by the waving (undulations) of undulipodia (cilia, *flagella* eucaryotes) that enabled single-celled beings to search for

food and shelter, to interact with other cells, to escape from danger or predators, and, in short, to survive. Today similar structures (of undulipodia) are found in the rod cells of our eyes and in the tails of sperm. The whipping movements of free-living protists are due to proteins similar to those found in the brain, i.e., microtubule protein. Thus, these movements that facilitate perception and the selection of external signals to make up "intelligent protist behaviour" or a form of "basic consciousness" have been transformed over billions of years into structures that carry out the intracellular neuronal movements through which we live and think. This movement continues to be basic to everything we need to assure the survival of our species: touch, perception of surroundings or communication among individuals. If we accept the fundamental continuity between body, mind and environment, then perceiving, feeling, thinking, breathing, eating or excreting are like the rest of physiology, the result of a web of interactions that define the chemistry of an organism.

The network of neurons and nerves that make it possible to write these lines share over 3,000 million years of evolution with the brain that is now reading them. This reaches from the origin of life up to today. The first neural structures (those of the craniates) appeared in the Cambrian Period some 540 million years ago. Palaeontologists place those early "human" brains on the African savannah about 3.2 million years ago (Leakey's "Lucy" in Olduvai). Our species, *Homo sapiens*, appeared approximately 100,000 years ago. The two brains that these paragraphs connect, regardless of their culture or background, share the same evolutionary branch that last forked one thousand centuries ago. This may appear to be a very ancient fork from our individual point of view but, in evolutionary terms, measured in geological time, it is very recent, just a finger-snap in the immensity of the history of the Cosmos. If, as Carl Sagan suggested, we compress the nearly fourteen billion years that have elapsed since the Big Bang into a single year, our species wouldn't appear until December 31 at 11:56:30 pm of that cosmic year. The Neolithic emerged twenty seconds before the end of the year. It is clear that humans are newcomers to the web of life that has evolved on the planet.



It is, however, astounding to observe the explosion of human diversity and sociocultural complexity that took place in those final "four minutes." Its shock wave has created and destroyed cultures and civilizations, languages and technologies, developed symbolic systems and equations, poetry, music and even humour like "secretions" of some thinking, feeling, hyperactive glands. The endosomatic interactions that produce thought correspond to the communicative processes

between thinking humans that make up the networks of minds that sustain civilizing and cultural processes. And thus “humans brain tissue has looked outside the frail skull concealing it for an artificial exocerebrum, exposed to the outside world, which provides it with a solid symbolic structure to rely on” (Bartra, 2003).[3] This tissue, made up of 6000 millon mind/bodies and growing fast, has colonized one planet, so far. The behaviour of this *primatemia diseminada* that James Lovelock refers to has disturbed the homeostasis of the Earth and this is seen in the purported anthropogenic nature of global climate change.

**Co-evolution**

The exobrain described by the anthropologist Roger Bartra resonates with the concept of noosphere (Greek, noos, intelligent) developed, at the beginning of the 20th century, by Teilhard de Chardin (1881-1955) and Vladimir Vernadsky (1863-1945).[4] For Vernadsky, who coined the term biosphere, humanity is a new evolutionary phase in the biogeochemical process that is Earth. This process includes human bodies as well as all the machines and artifacts we have created in coevolution with the environment. Life, including human activity, “doesn’t ‘adapt’ to a passive environment (...). Instead, it actively



produces its environment and modifies it. In contrast to a mechanical world focused on physics, the metabolizing biosphere regulates itself physiologically” (Margulis, 1990).[5] In this context, the body of each thinking being, with its symbolic extensions and peripheral technologies, constitutes the material and cultural *hulls* that make up humanity’s exobrain network. In turn, each body/node in this mesh, each human being, consists of endless modules and endosomatic sub-networks on different scales, with constant different atomic, molecular, metabolic, cellular, neuronal, endocrinological and muscular interactions that participate in social, affective, linguistic, cultural, technological or ecological exosomatic networks (Guardans, 2003). It is astounding to think that our circulatory system would wrap around the world twice if stretched out, about 100,000 kilometres, while it only makes up three percent of our body mass (Schiefelbein, 1986). Likewise, the very fabric of “humanity” as a whole is only one small sub-network in the planetary “nervous system”: myriad currents of signals and interactions in constant flux. We are barely starting to see and understand this “system,” from its quantum, molecular or biological communication networks to its social or ecological networks. We do know the genome sequence of many organisms, which is not insignificant, but there remains much to be done before the complexity of the interaction of the signals that lead from the genotype

to the phenotype of the simplest organism can be revealed. This poses a stimulating challenge for science and technology as well as a humbling reminder and cautionary tale regarding the ethical, sociocultural and ecological consequences of tampering with life.

Paradoxically, while humans are destroying many of these networks that sustain us — trophic food, linguistics, emotional, societal and ecological — the paradigm and culture of *the Network* has surged into existence. This movement could be interpreted as an immune-like, intelligent reaction in that it appeals to measure, proportion and context. In other words, this same pattern of organization, the network, that hastens the poisoning of the environment, the repression of citizens or new forms of terror, war and crime, also leads to the generation of "antidotes" against some of these problems. We are not referring to the naive view that the network, in a natural way, can solve all problems, since, as we have already seen, the global network we inhabit can, with the same naturalness propagate pathological behaviours, toxic substances and epidemics. A good example of this ambiguity can be found in the development of the primitive Internet. The military threat to the United States that caused missiles to be installed in Cuba in 1962 led to a defence strategy that later evolved into the World Wide Web that we all know. The threat or awareness of death activates the life force and builds pathways. "Smarter than hunger" is a popular Spanish saying that captures this idea. Stated frankly and with no apocalyptic overtones, our species finds itself in a situation where it has nowhere left to turn on our planet. There is no place left to stealthily dump the excesses and wastes of one group on another. The web of life reveals how destructive actions against the environment end up affecting all of us. Networks and mass communications, radio, television, the Internet, and satellite comunications, show us the consequences of greed, envy and local abuse. This is the new situation that global change confronts us all with (Carpintero & Naredo, pp. 285-292). The set of economic, social, ecological and cultural indicators describe a common dilemma. We are all in the same boat, on a course that the planet cannot sustain.

**Fragmentation and uncoupling**

Decades ago, David Bohm, the American physicist who collaborated with Oppenheimer, pointed out that the problem was not the events that we face but the thoughts that generate those problems and also constrain our reactions. All frontiers are erected by thought. The fundamental dissociation between mind and body implicit in "western" thought carries with it a pathological drive that years later has manifested itself in all its power. The radical split between human beings and nature, the organization of knowledge into closed compartments and the quantification of the world to the detriment of the qualitative, have led to a complex, collective, global pathology. To oversimplify, some of the symptoms of this crisis are the anthropocentric alienation and linear, dichotomous, instrumental thought that have characterized, perhaps since its origin, that talking primate who evolved on the African savannah. The truth is that this type of thought has been shown to be very efficient. So much so that it has spread all over the planet, becoming a plague and, as a consequence, devouring and imposing itself on any other way of conceiving, thinking, or being in the world. But this monoculture, by its predatory nature, has finally become a dangerous enemy even to itself. In fact, just as the losses in biodiversity pose a threat to the trophic networks that sustain ecosystems, loss of cultural diversity leads to a lessening of the adaptive capability, of versatility and of sociability, all of which are needed to assure the survival of our species (Montoya, Rodríguez, Solé, pp. 299-307).

In counterpoint, we have seen how this reticular vision of the world has vigorously re-emerged and evolved in western culture since the 20th century to become one of the paradigms of the current Information and Knowledge Age. This involves a new vision that has transformed biology, physics, the economy, sociology, neuroscience, politics, the arts, communication, activism and consciousness. But perhaps the most important aspect of this vision is that it is changing the relationships among these fields as well as their interaction with society. That is to say that the network template is transforming the structure of knowledge and the behaviour of human groups. Although it is quite clear that it is an ancient template, it still resonates with origin myths that "other" cultures and civilizations hold dear. Despite the "West's" disdain for them as archaic, rudimentary or primitive, such myths have profound correlations to complex current ecological or systemic thought.

**Structures of the exobrain**

Human history is a chronicle of the emergence, development, decline or transformation of different types of generation, organization, conservation and transfer of knowledge. Ever since Neolithic times human societies have tried to preserve collective knowledge as a valuable resource that improves living conditions and chances for survival. It has always been coveted by human individuals and groups in order to gain power, converting its control into a source of tensions and conflicts. This is evident in the control that the inner circle of Egyptian priests exercised on the scribal caste, in the power the Church wielded over medieval monasteries and universities, in the resistance to the printing press when it first appeared due to its emancipating potential, and in the numerous forms of censorship that have appeared throughout history. Since the Renaissance, in an attempt to adapt to the discovery of new worlds and to increasingly complex sociocultural structures, new institutions and structures have arisen to try to manage the new situations generated by our eagerness to know and exchange knowledge, to reach out to other regions, to conquer nature and to control other human groups. Religions, churches, sects; monasteries and universities; salons made up of intellectuals and researchers, academies, disciplines and publications; factories and craft guilds that favoured the Industrial Revolution and the proliferation of associations and societies, the creation of polytechnic schools, professional bodies, museums, congresses, specialized journals, universal expositions, lobbies of all kinds... in short, the evolution of knowledge throughout history has taken different forms based on each culture as well as on the available technology of each age. The establishment of instruments and entities to organize and manage knowledge was, as pointed out by García Camarero (pp. 119-130) and Echeverría (pp. 215-221), determined by the dynamic tension between forms and institutions that are imposed from above and the collectively constructed forms that surge up from the grassroots. The manifestation of this dual process has resulted in a map of structures, disciplines and institutions that, as a whole, make up what could be known as the "genome" of the human exobrain.

As we mentioned in the prologue, little more than a century has passed from when Ramón y Cajal announced that, for the first time in history, a neural network had been observed by itself, to the current moment,when this same system of networks allows us to observe ourselves socially and collectively. Manuel Castells (*The* "network society"), Derrick de Kerkhove (*Connected Intelligence*), Javier Echeverría, Pièrre Lévy (*Collective Intelligence*), Fernando Sáez

Vacas (*The Universal Digital Network*) and Fritjof Capra (*The Web of Life*) among others, have all mentioned this. Today we face the challenge of closing the cycle, of reconnecting current schools of thought and human actions to the bacterial networks that originated them all. To link the behaviour of neural, cognitive, electronic and social networks with the biological and ecological networks that sustain them all.

**Biomimesis, innovation and sustainability**

The Information Age is also the Age of Global Change. These are two aspects of the same complex dynamic that confronts us with an array of new social, ecological, economic and cultural problems that are systemic. The interdependence of these problems overwhelms traditional linear, compartmentalized organizational and management concepts. They demand an urgent change in perspective, sensibility and behaviour. This change depends, in large measure, on how contemporary societies perceive such problems, thus making their communicative and educational challenges of the highest priority. Given the gravity of the ecological crisis in the current global situation, we must attend to the processes, strategies and behaviours that the web of life uses to deal with ecological problems. This observation led to the idea of biomimesis, as an attempt to direct ways of human production towards a reconnection with natural dynamics. It is not futile to see life as an R&D process (Research&Development), based on trial and error and subject to natural selection, that has maintained itself for almost four billion years. Humanity, including the constructs and discourse of its brain, is the result of its biological evolution and to deny this would be as contradictory as continuing to nourish the current model of production and consumption without taking into account its ecological footprint. All this requires a holistic, systemic, transdisciplinary outlook, where techno-scientific progress and emerging social dynamics and artistic practices reveal new perspectives and action strategies to take on these issues in a critical, innovative and efficient manner.

It is quite true that, through force of repetition, “innovation” has become the new all-purpose mantra of contemporary society. We use this word to embellish everything we make and do, from advertising yogurt and cars to political, economic, scientific or cultural policies. In this way, information societies show themselves to be stultified societies which avidly hunt down mere data, which is neither information nor knowledge, or new or “innovative” concepts, then empty them of all meaning before they have a chance to take root in society, thus nullifying any potential they might have had for change. This is happening to some degree with the concept of “sustainability.” After the Kyoto Summit, from one day to the next, companies, policies and products that had no respect for the environment became ecological in a hypnotic cosmetic operation whereby they simply changed the colour of their trappings to “green” without changing, in any way, the conditions and behaviours that make them unsustainable. However, these skin-deep, narcotizing distortions — known as “greenwashing” — should not distract us from the value that the combination of these concepts, “innovation” and “sustainability”, can have in meeting the challenges we face today.

To clarify the meaning of innovation in the context of this article, we can identify various degrees or levels of innovation identified by current economic and industrial trends where this concept has acquired primary strategic importance.

1) Sector innovation (product or process): the modification of a product or process that affects the very substrate it emerges from. This is often confused with insignificant superficial changes or improvements of a product that in no way modify the context of their production.
2) Inter-sector innovation: collaboration between different sectors with the aim of developing a new product or process that expands their former sphere of influence or even leads to the appearance of a completely new field. Today, scientific and artistic innovation occurs on the boundary between different sciences or areas of research.
3) Innovating the innovation. This type of dynamic examines, optimizes and applies the emerging trends generated in the development of levels 1 and 2.
4) Eco-innovation or biomimetic innovation: this level deals with the study of the ecological and sustainable aspects of innovation processes. That is, it addresses how to go about integrating a transversal factor into the innovations of levels 1, 2, and 3 that monitors ecological footprints in order to develop an environmental, social and symbiotic ecology with which to promote energy efficiency. In other words, can we invest in uncoupling the humans *versus* nature tendency and construct new production models that harmonize human and natural economies?

For over a decade, the *banquete* project has been carried out as an experiment in biomimesis, exploring this fourth level by seeing innovation as an action that can transform the substrate of a given process, programme or product. To do this, *banquete* monitors the convergence of biological, social, technological and cultural processes. The study of how living beings transform the chemical composition of the Earth's atmosphere is an outstanding example of this convergence in that it connects planetary "biogeochemical innovation" with sociocultural and techno-scientific practices such as the development of open code and life sciences which are products of the *Information Age*.

The transformation of the Earth's atmosphere from its original oxygen-free composition into the current "breathable" one is probably one of the greatest processes of innovation that has ever occurred on the planet. It was carried out, on a planetary scale, by myriad microorganisms that achieved sustainable macro-behaviour, altering the Earth's biosphere.

Some of the living beings that populated the oceans two thousand five hundred million years ago began to generate oxygen as a byproduct of their photosynthetic metabolism, and this gas oxidized all of the susceptible compounds in the hydrosphere. Once the oceans had absorbed all the oxygen they could, the gas started to be released into the atmosphere until, a billion years later, current atmospheric levels were reached. Oxygen is, however, toxic for many living beings and so its increase led to the evolution of "detoxifying" systems such as aerobic respiration. Life produced oxygen, our planet changed and life adapted to a new oxygen-filled world. This story is a good example of co-evolution between life and the planet, a process that has managed to regulate the conditions needed by the evolution of life despite successive alterations and climate changes. This immense network of sustainable eco-innovation, which is basic to our survival as a species, is a "micro" dynamics with "macro" consequences based on the open, horizontal and massive transmission of signals with "no one" in charge. That is due to the fact that networks of global communication and behaviour started on a bacterial level billions of years ago. It should be noted that integrated climate study, mediated by the hydrosphere-atmosphere dyad, favours the development of an inter- or trans-disciplinary approach, since it deals with a phenomenon that includes the interaction of a

multitude of processes on different scales. This reveals another key characteristic of networks and their patterns: their freedom from scale (Solé and Munteanu, p. 310).

These characteristics of the web of life, open, horizontal information transfer and communication and interaction among different scales represent some of the most innovative practices of the Information Age. Open code and free software have transformed the ways knowledge is generated and transferred on a global scale. The model for this emerged from a civil society based on leaderless cooperation, analogous to the bacterial behaviour mentioned earlier (Guiu, 2003)[6] that has modified scientific research methodologies, the organization and management of many public administrations and the business models of a considerable number of companies, including software, information or knowledge-based industries and businesses (Martín Prada, pp. 180-199). In addition to its practical uses, this movement has modified social relationships among its users generating a culture of on-line innovation based on "hacker ethics", described by Pekka Himanen[7] as an open and cooperative culture, driven by its creative passion for researching, developing and sharing new knowledge and experiences. This movement, promoted by Richard Stallman, arises from the sociocultural, political and economic restlessness that has appeared as an alternative to the closed, proprietary attitudes of software and knowledge development and distribution. The correlation between this alternative culture and the web of life's networks of innovation plays a significant role in promoting a global ethic that has melded the terms "ethos" and "eco." These terms have now become inseparable from new ways of acting on the world.

Also, the culture of on-line open code has had an impact on the life sciences. Today research groups all over the world share huge databases that are essential to the advancement of our understanding of the basis of life. These questions can only be addressed collectively; an individual node cannot deal with them. This is how the web of life demonstrates its systemic nature. This situation brings to mind Humberto Maturana's 1980s statement that communication was not just the mere transmission of information, but also implied the coordination of behaviours. From the power of "we" proposed by Imma Tubella (pp. 210-214), we might be able to approach an understanding of the web of life. It is not in vain that each human being is a "we." That is, each one of us is an integrated community of organisms in a symbiotic relationship. 10% of the dry weight of a human body is made up of bacteria and other microbial symbionts without which we would not be able to survive. In fact, every single cell of our body is a "we", a symbiotic community of components, cellular organelles such as mitochondria, which had lived independently as bacteria previously (Folch, pp. 293-299). Moreover, in the last decade we have learned that almost half of our genome comes from genetic fragments that were originally in the genome of other species and that over the course of evolution have reached us by means of "transporting elements" such as retroviruses. This tells us, first, that viruses and not just bacteria have made us what we are, and, second, that our genome, like the genomes of all living beings, is a mosaic of other genomes. An information puzzle. We wouldn't exist without the rest of the biosphere.

The biomimetic question, suggested by these analogies, is whether we are capable of integrating two apparently unrelated and at times diametrically opposed cultural threads; ecology and digital culture into the same process. The challenge is how to make proper use of infotechnology coherently to confront environmental degradation, by turning a corrosive and degrading to social and environmental dynamic into a more constructive and ecologically concerned one. In other words,

how to integrate Fernando Sáez Vacas's digital noomorphosis[8] (pp. 150-156) with the five principles of ecoliteracy proposed by Fritjof Capra — interdependence, recycling, association, flexibility and diversity — to develop an ecological organization that promotes the reconnection of humans with the planet (DeFelipe, pp. 85-96) or, at least, a co-evolutionary vision of both approaches that puts technology at the service of the environment instead of the reverse (Valencia, pp. 60-64). Maybe this integration or co-evolution can help to overcome the egocentric excesses and alienating anthropocentric beliefs that have been nurtured by the dominant western culture.

Paradoxically, in their period of greatest dominance and power, humans find themselves overwhelmed and fragile when faced with extreme weather phenomena that result from climatic and global changes, in which we play a decisive part. Actions that derived from predatory ways of thinking about nature return with unsuspected and confirmed virulence. The most plausible strategy to avoid this situation seems be to eliminate all unnecessary consumption, or, at least, to reorient it towards obtaining energy efficiency and promoting an "ecosophy which unites environmental ecology with mental and social ecology."[9] Also, the extravagant behaviour associated with the imperialist and neo-colonialist tradition shows signs of exhaustion. A dialogical and receptive attitude of re-connecting with the environment is seeping through its cracks. Beyond any ideology, this change encourages new survival tactics; coherent and consistent actions that affect us as a species. In this context, the junction of art, science, technology, society and environment (Spanish acronym ACTSA) represents an emerging process with great potential for the production of innovation, value and wealth, and constitutes a key vector for the stimulation and democratization of R&D culture.

In the Information and Knowledge Age, biology and technology, science and conscience, ethics and sustainability, are all part of the same system. We must ask ourselves if we are able to redesign and reorient our cultural institutions and social structures according to this new paradigm. Can we collectively devise, from a biomimetic perspective, new social organizations that behave with the same fabulous plasticity and functionality shown by cellular and neuronal structures, or even our own systems of sensing and communicating? Is it possible to generate and transfer knowledge based on an eco-physiological vision, more akin to metabolic and informational processes than to rigid, mechanical and compartmentalized determinism? Could a perspective with these characteristics help to reconnect and recombine that which might be divided only in our minds?

**Symbiosis, trans-disciplinarity and cultural networks**

Symbiosis is the mutually beneficial shared life, in physical or metabolic proximity, of different organisms. Stable long-term symbiosis that leads to evolutionary change is known as symbiogenesis. This refers to the origin of new organelles, tissues, organs, organisms and even species by means of permanent long-term symbiosis. These associations, true biological fusions, are a powerful motor of the evolution of species. Two organisms from different species unite and, after evolving together, produce a third organism. From a symbiogenic point of view we can interpret the ACTSA environment as an emerging cultural process that generates a fluid, permeable and trans-disciplinary body of knowledge that can relate and integrate diverse and dispersed, previously independent, disconnected elements. The properties and structures of this dynamic "body", with its changing forms, arise from the network of flows and interactions among different ideas, subjects, entities and institutions that, in turn, organize the system and thus determine its functions, physiology and behaviour. Their develop-

ment requires a new set of conceptual instruments of a systemic nature along with novel organizational and management tools that encourage their evolution, transfer and social implementation. The aim is to structure the atypical, trans-disciplinary and inter-institutional routes that maintain the metabolism of ACTSA entities. These routes, most of which are not clearly established, generate unusual alliances and consortia among subjects (creators, researchers, managers) and entities (collectives, institutions, businesses) that discover that they have complementary properties and functions within this new context. The consolidation of these environments requires a communication system that facilitates collective identification and self-observation of the process itself and promotes trustworthy networks to encourage and sustain them. From this dialogue and interaction new "symbiogenetic" ways of thinking and doing, new transversal practices and discipline, new entities and institutions can evolve. A crucial aspect of these dynamics is the importance of contact and coexistence with other realities, sensibilities, languages and methodologies to ensure one's own awareness. To this end, the creation of uninhibited, undisciplined situations can encourage the emergence of collective creative processes that integrate diverse participants from different fields of knowledge and experience. It is important to emphasize that these ACTSA processes, by definition, put concurrence before competition. Thus they can be complementary and interstitial in relation to current hyper-specialized, departmental structures.

All of the above-mentioned makes it a first priority to develop hybrid structures that facilitate cooperation. They must be able to manage and collaborate with both institutional structures as well as grassroots movements that channel the creative drive of citizens and communities. Unfortunately, we see too many waning entities that attempt to imitate emerging networks in an effort to domesticate or neutralize change by trying to co-opt the dynamic network space with strategies anchored in a classical concept of space, understood as a closed and static container. This perspective fundamentally contradicts current knowledge of the world and is a permanent source of conflict and frustration. In addition, it is profoundly unsustainable, since is wastes a great deal of energy and resources on trying to legitimate itself with meaningless, expensive, highly visible, cosmetic advertising campaigns to shore up the sham. Managing and resolving the conflicts that are constantly created by this obsolete dynamic, leads to stagnant public administrations. To deal with this situation, it is imperative that new structures be made available to these processes of innovation rather than continuing to attempt to control and exploit them. Manuel Castells states that, "when governments or large companies take control of innovation they wither them. This is not an opinion, but the result of two decades of experience observing them."[10] He concludes by saying, "this means of innovation can't be designed. It forms organically, spontaneously and even accidentally, but it can be destroyed if deprived of an adequate institutional, financial growth medium of tolerence and liberty."[11] Thus it is no longer acceptable to speak of an Information and Knowledge Society while ignoring or scorning the new processes of artistic, scientific, technological, social and environmental production and dissemination that are emerging in the "network society". Nor is it admissible to promote a culture of innovation (R&D) and, at the same time, penalize creativity for being too new or inconvenient. These schizoid contradictions, written into current systems of production and transfer of knowledge, must be overcome (A. Rodríguez, Marzo, N. Rodríguez and Eraso, pp. 180-199).

Nevertheless, many of these emerging artistic practices, openly hybridized with diverse forms of activism and/or techno-scientific development, spend their energy on generating structures,

processes and tools to facilitate a shared creative drive rather than on creating artistic objects (Guallart, pp. 251-252). It becomes more important to achieve a certain dynamics than a hypothetical final object, since the result is the transformative potential of the process itself. The relationship between author, work and public becomes a creative, open and collective process that evolves from the interactions between the actor/agent participants in these new innovation environments. In this manner, the concept of audience as consumers of "closed" objects moves towards the idea of consumer as participant in the process of reciprocal learning exchange that creates communities with shared motivations and interests. This sharing acquires new qualities of consistency and courage. "Network as Artwork", as Roy Ascott said in the 1970s. Likewise, the static concept of space is transformed into a malleable geometry and thus into an event that emerges from the movement and interaction of its elements. "Network Space" defines its identity and function according to the flow of information, the dynamics and the network of interactions it is a part of (Briones, Manrubia and Martín-Gago, pp. 49-57, Corrales, pp. 131-137).

This knowledge and experience, accumulated over decades, should be borne in mind more often when devising cultural, educational, and environmental policies such as R&D, and even to strengthen their synergy, since in the current network system it is meaningless to conceive of them as separate entities. One of the key issues in the transition from a fragmented or segmented pattern to a systemic, networked one is that, within the latter, each component of the system can contribute to the production of other components or to the common substrate. Hence, constructing the network can be a community-building process. Networking also encourages non-linear feedback loops as opposed to classical linear, sequential and compartmentalized models that tend to limit the system's communication and functionality, resulting in the isolation of its components.

**Noosphere and e-proprioception**

As mentioned earlier, Vladimir Vernadsky's concept of the "noosphere", posed in the 1920s, referred to a new evolutionary geological change in the biosphere. According to this, the presence of humans represents another phase in biogeochemical evolution. It is a special layer of organized thinking material that grows on and changes the surface of the Earth. The change has accelerated dizzyingly, first during the industrial revolution and now in the microelectronic and nanotechnological revolution. Vernadsky believed that humanity and technology are an accelerated but integral part of the planetary biosphere. It is true that the anthropogenic roots of the current climate change are related to these accelerations. But today it is also possible to use these communication networks to bring the visionary noosphere into focus and develop a new collective, electronic and distributed proprioception[12] that could be called "e-proprioception." "Proprioception, the perception of movement and orientation in space that comes from stimuli within the body, is a physiological concept. Our proprioceptors constantly inform us of whether we are standing, tilting our head, tightening our fists or moving at 50 kilometres per hour. Proprioception, sensing oneself, is probably as old as our sense of being ourselves. Herds of extinguished dinosaurs, and other animals before them, already enjoyed the benefits of their own proprioceptive social communication; the global nervous system didn't start with the origin of people. Physiologically regulated, the Earth benefited from global proprioceptive communications long before we appeared. Gas emissions and soluble chemical compositions from tropical plants, insects ready to procreate or bacteria under threat of death

circulated through the air in our atmosphere. The speed of proprioception has, however, increased enormously in the electronic and digital age." Although these ideas have been "percolating" through different cultural settings for decades, the current increased access to knowledge and technology can boost the democratization of artistic and scientific creation and research. Their methodological and strategic similarities and the fact that artists, engineers, scientists and activists all share the same languages and tools encourage trans-disciplinarity, the creation of open platforms, spaces and processes which generate new ways of relating among institutions, citizens and settings.

The first images of Earth as seen from the Moon were globally broadcast on television. This is a good example of the sociocultural impact of electronic proprioception. The science and technology developed over decades was transformed into symbolic energy, a commonly felt experience. Today's electronic propriocetive network with its multiple-scale accesses, from planetary to nanometric, local to global, could lead to the development of José María Baldasano's (pp. 308-309) cooperative global vision as stated in his description of climate change. It becomes imperative to add value to the cultural dimensions of scientific and technical research and development processes. The symbolic energy implicit in scientific information can multiply the value of what, from a strictly utilitarian and quantitative point of view, is considered mere data. Art, science and thought are artificial categories that should not create ghettos, isolated from social and environmental realities. Thus it is vital to encourage a broader social perception where science and technology are considered cultural expressions and art and literature are accepted as forms of knowledge in one integrating process of social innovation.

It is important to remember that about every thirty years, the number of scientific disciplines has doubled. In the early 1970s there were three or four thousand. Nowadays, the number is closer to seven or eight thousand. With reductionist analyses, there is no need to integrate disciplines since entities are studied in isolation, then "frozen" and analyzed as closed systems. In order to deal with the challenge of global climate change and to understand the cycles of life, a holistic approach that integrates disciplines is needed, since these are open systems. As Pedro C. Marijuán states, "a biological wisdom of the flow of information that integrates open systems has not yet been achieved by science." The mechanical reductionist model used in the natural sciences to date has succeeded at the expense of a loss of integrative vision that has made consciousness, emotions and creativity disappear. The time has come to explore and devise new relations among all these dimensions.

With the goal of exploring this new proprioceptive network, the R&D programme *Nodos y redes*[13] is developing on "e-biolab" in cooperation with an international network of researchers and creators, along with research, training, production and cultural outreach centres, ACTSA (Art-Science-Technology-Society-Environment).

**e-biolab**

e-biolab aims to contribute to the construction of socially and environmentally sensitive cultural networks that are able to flow easily from nanometric to ecological or planetary climate scales. These are complex networks of eco-innovation and cultural communication linked to and in tune with the networks of life. These networks interact in a "Gaian" manner. They accept the biosphere, lithosphere, hydrosphere and atmosphere as parts of the same planetary system that includes us and, in turn, commits us to practice a new social, cultural, ecological and technological ethic on

an equally planetary scale. It must be said that we are not speaking of cultural totalities. As Edgar Morín said, "the very idea of complexity excludes the possibility of unification since once uncertainty is taken as a given, the inexpressible must be faced."[14]

With its biomimetic focus, the Ebiolab on-line platform operates as a system that connects and mediates among processes, disciplines and institutions to promote new hybrid entities or the creation of trans-disciplinary dynamics and communities. It is a transmitter of what is happening in education, the environment, industry or international cooperation. Its function is analogous to the behaviour of certain genes or proteins in relating diverse interactive networks: the key role that nodes connecting these networks, or the modules within them, acquire. Although early on more emphasis was placed on the study of well-connected nodes, which in biology would correspond to genes whose mutation is lethal to an organism or produces significant changes, it has become increasingly clear that genes that are crossed by many paths, connecting groups despite having few connections, carry out a fundamental role in the organization, evolution and functioning of networks. These genes act as bridges between functions. Biology considers them connectors of different functional groups that transmit, for example, what is happening in metabolism to what is happening in regulation. They are the intermediaries between processes although they appear to have no fundamental role in any of them. This highlights the catalyzing potential of the so-called "weak connections" in the evolution of networked systems. One example of this was when the misnamed "junk DNA", after being scorned for years because it didn't codify proteins, recently attained unexpected relevance and influence in the regulation of gene expression (Marijuán, pp. 142-149).

To develop these eco-innovation processes, Ebiolab extrapolates to the realm of knowledge generation and transfer Salvador Rueda's sustainability equation (pp. 254-259) in which he compares the energy efficiency of natural ecosytems with human production systems. The idea is to manage the increase in complexity without increasing the demand for resources or, even, reducing it by means of cooperative development strategies. In other words the tendency to hyper-specialize overrates the main activities of institutions, entities and businesses to the detriment of those secondary activities that, ignored by specialized competitive pressures, become undervalued residual forms of knowledge. The idea is to recycle this type of knowledge, presumed to be secondary, and add value to its connective potential in order to create new relationships and hybrid environments. This would, in addition, allow new sustainable and reproducible models of knowledge generation and transfer, ACTSA, to be designed. From this point of view it is possible to experience new production relationships that transform the linear concept of the "science-technology-industry-society" sequence into another based on complex non-linear relationships among research-training-production-communication-outreach.

Another important requirement is to promote free access to knowledge, since free-ranging knowledge, due to its enormous multiplying effect on creativity and the production of new knowledge, is one of the greatest treasures of an emerging society (Alsina, pp. 138-142). This in turn encourages citizens to accede to and participate in not only expositions of the results, but also the processes of researching, creating and producing them. The situations that emerge from these apparently chimerical processes have great innovative and productive potential that is aided by the emphasis given to creativity that dominates these innovation strategies and policies. Scientific institutes and laboratories in partnership with companies would develop artistic creations that feed their own processes and research contexts back to them. In the same manner, artistic, intellectual

and social collectives provide knowledge and experience, not only to foster the development of new scientific and technological research and development projects and strategies, but also an ethical and yet critical vision. This type of dialogue leads to a system of reciprocities that enliven and inspire new artistic endeavours which in turn also influence scientific and technological research and innovation. All of these allow new forms of producing and transferring knowledge, creating value and wealth along with new sources of employment to be explored.

In conclusion, Ebiolab is an attempt collectively to construct productive models based on an ethical and eco-physiological vision of the generation and transfer of knowledge, both to increase social and ecological consciousness and to respond to a change in the knowledge model paradigm since biological forms and structures that are basically homoeostatic are making it possible to supersede mechanical models. E-biolab is open to new ways of thinking and acting and to improving the integration of societies in their natural environments.

**Summary**

As mentioned in the prologue, the original 2003 edition of the project called *banquete* examined the correlation between lifestyles and communication, exploring analogies between metabolism and communication, understood as processes of matter, energy and information transformation. In 2005, the second edition emphasized the evolutionary character of both processes. In this third and last edition, it explores the underlying reticular structures below the processes of life and communication, as well as those of social, economic, cultural and ecological dynamics.

One century ago, science had to overcome the dichotomy between the observer and the observed, and had to renounce objectivity in order to be able to better understand the phenomena and processes it was investigating. Heisenberg's Uncertainty Principle changed the course of science. This fact has influenced or been in synchrony with similar situations in other fields of cultural and social dynamics throughout the 20th century: from the question of the "art-life" dyad, the idea of the open-ended work of art and the transformation in the relationship of author, work and audience in the context of interactive art, to the emergence of different forms of activism and citizen participation in the collective construction of reality. On the verge of the 21st century, the concept of an open network and shared knowledge might be the construct needed to transform the very substrate of both the means of production and the transfer of knowledge. In this new emerging context, aesthetic experience, the democratization of scientific and artistic knowledge, ethical commitment and participative action are all part of the same shared creative stream. It is a stream that, in fact, follows the path taken by life on our planet. It is no longer enough to think about problems and write reports that only experts read, or to mount strategic educational campaigns about isolated issues that respond to the needs of whatever political party is in power. A new range of possibilities for negotiation and collectively constructed as well as distributed knowledge and experience has been made available.

Every change in the paradigm entails a process of adaptation. "In revolutionary France, neither the classical universities nor the academies sufficed to generate the necessary knowledge to build a new society" (García Camarero, p. 127). The new consciousness appeared from "beyond the pale", precisely from the recognition and legitimation of the excluded. In fact, it was after a century and at the "Salon of the Rejected", where the first "impressionist" vision emerged and claimed as its own the newborn 19th century. But, actually, we always encounter the same sequence of events. It was not in

vain that philosophy and science, as we understand them nowadays, were developed by a generation of intellectual outsiders, in both pre-classical Athens and the temples of mainstream knowledge. Exemplary thinkers including Thales and Anaximander of Miletus, who, with the same curiosity they used to study the atomic roots of matter, dared to examine both the Cosmos and Man and made both disciplines compatible. As Rasskin-Gutman and Delgado pointed out (pp. 78-84), in the field of life, the anatomy of the network determines behaviour and, as a result, its functions. It is fitting that we explore the properties and condition of the current structures and networks of communication, which mediate the new social practices, as well their production dynamics and knowledge transfer systems in order to try to overcome the as yet unsolved antagonism between development and sustainability. This equation forces us to reorient infotechnologies towards a social, open and humanist model that will reconnect us to Earth and to the processes of life.

It is an old debate, but the new field of negotiating among an unprecedentedly heterogeneous profusion of forces and tendencies offers, as we have been able to see here, new conditions with enormous transformative and innovative potential. Both philosophy and the emergent physiology that connects biological, electronic and cognitive aspects, challenge us, individually and collectively, to take on this new point of view and new consciousness. The resulting macro-behaviour depends on the sum of and interaction among the micro-actions carried out by each individual. If, as Lynn Margulis states, we are symbiotic beings on a symbiotic planet, it is not strange that our behaviour, as well as our social and cognitive structures, interact and evolve symbiotically. Perhaps, this evolution can take place in an open and participative manner, at once trans-disciplinary and transversal, capable of reaching critical mass and acquiring true power to perceive and activate the right strategies at the right time to confront our global crisis.

**Notes**

**1** Margulis, L., Sagan, D. (1997): *Descartes, Dualism, and Beyond in Slanted Truths. Essays on Gaia, Symbiosis, and Evolution*, New York.

**2** Protists led to the evolution of plants, animals and fungi. The Protist Kingdom includes amoebas, ciliates and all algae, making it an extremely diverse Kingdom.

**3** Bartra, R. (2003): *Consciousness and the Exobrain*, published in *banquete_metabolism and communication*. In press.

**4** Vernadsky, V.: "The Biosphere and the Noosphere", *American Scientist* 33:1 (January, 1945).

**5** Margulis, L. (1990): "Big trouble in Biology: Physiological autopoiesis versus mechanistic neo-Darwinism", in *Doing Science: The Reality Club, 2*, New York, pp. 211-235.

**6** Guiu, L. (2003): "Open Code and Bacteria", in *banquete_metabolism and communication*. In press.

**7** Himanen, P. (2006): "La ética *hacker* como cultura de la era de la información", in *La sociedad red: una visión global*, Madrid, p. 505.

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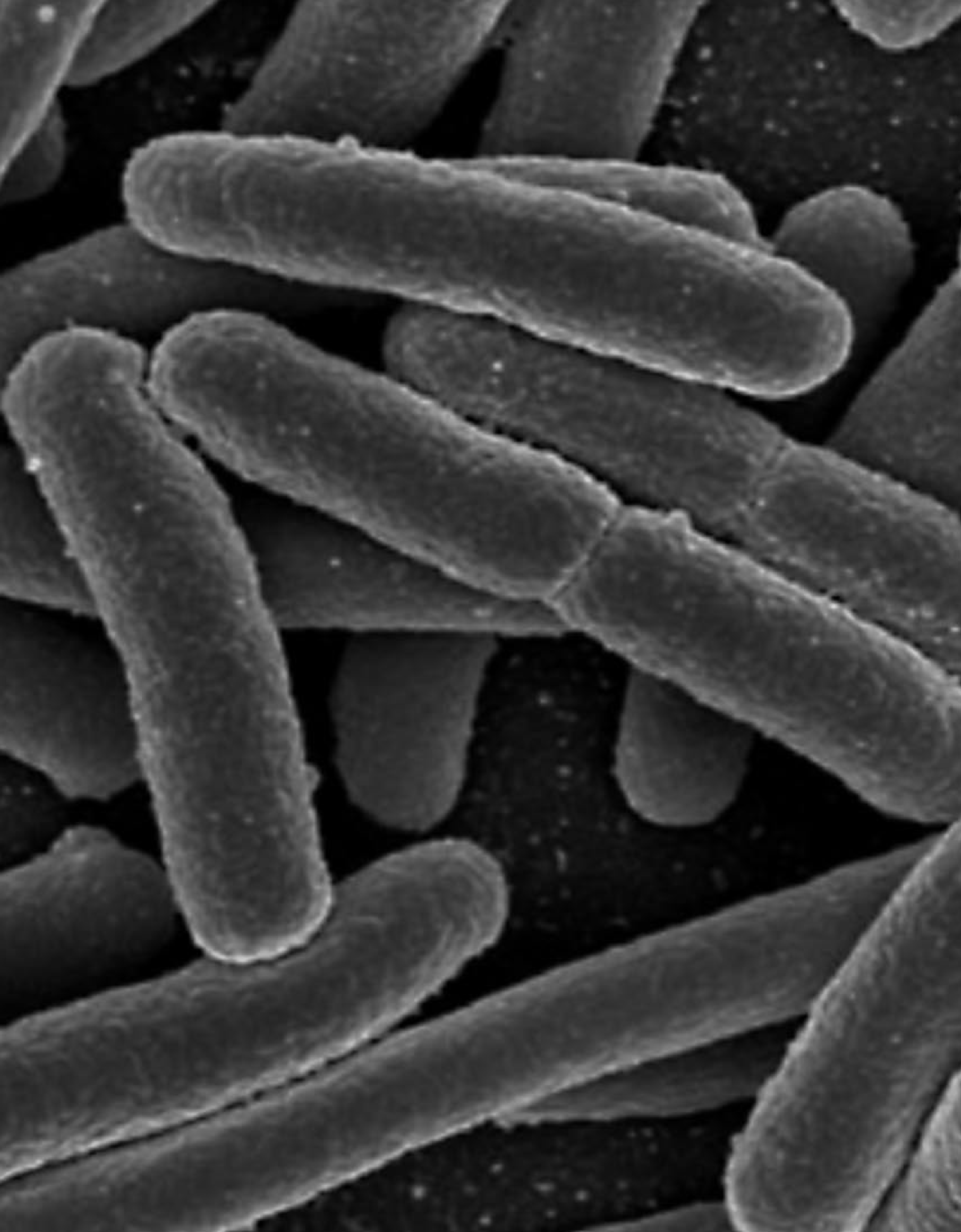
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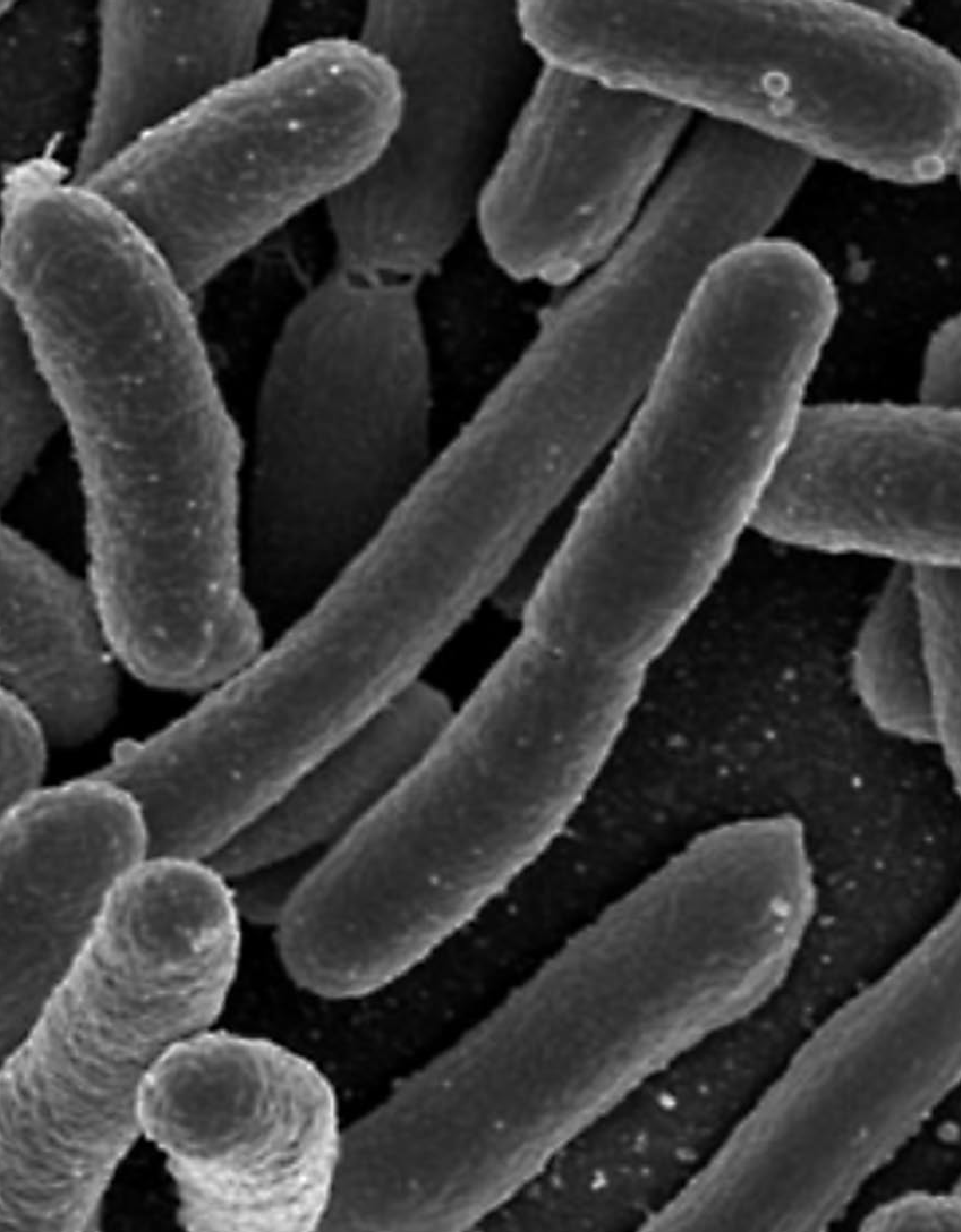
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***Networks provide an identity to the parts of the system. We are built, life is built, organized and selected in the rhythms of the system's relationships. (...) Life as a process whose motion started billions of years ago and is still ongoing. All of it thanks to networks.***

**Ángela Delgado and Diego Rasskin-Gutman**





# Trapped in the network: nanoworld, life, society

Carlos Briones
Susanna Manrubia
José Ángel Martín-Gago

Bacterium *Escherichia Coli*

## 1. Networks in the nanoworld

When we observe the world around us, we perceive that inorganic as well as organic matter, inert materials as well as living beings, are characterized by an ability to self-organise forming structures and networks. Atoms arrange their electrons in a rigorous manner; molecules assemble or interact with each other in coordination to construct structures of higher complexity... Nature's fixation with organization has aroused the curiosity of researchers, who have attempted to make out the hidden order of multiple systems and processes to better understand the fundamental mechanisms and laws that govern such organizational networks at every level.

It is obvious that in order to form organized structures, an electron, an atom or a molecule need to recognize similar units and behave in a specific manner by means of some sort of *force*. Today we know that four types of interactions or forces govern natural processes. The influence of the first two can only be felt at minute

distances, shorter than atomic nuclei (of the order of a *femtometre*, that is, a billionth of a millimetre): the strong nuclear force is responsible for holding the units of the atomic nucleus together (protons and neutrons); on the other hand, the weak nuclear force has to do with the interactions between the particles that form protons and neutrons (known as *quarks*) and makes possible certain types of natural radioactivity.

In contrast to these, the other two fundamental forces are long-range: since their effects can reach any distance, in principle their action extends to infinity. Besides, we are much more familiar with these two forces, since they rule the processes that our senses can perceive. Gravitation, or gravity, is the mutual attraction experienced by two objects as a function of their mass, and it is responsible for large-scale movement in the universe, for instance the organization of the planets around the Sun. It is also responsible for our having "our feet on the ground" and for apples falling off trees. Last of all, electromagnetism governs the behaviour of matter as a function of its electric charge, and can be attractive (between particles with different-sign charges, such as the electron and the proton) or repulsive (between same-sign charges). The electromagnetic force is involved in the physical and chemical transformations undergone by atoms and molecules, and is responsible for the formation of structures — and networks — among them. Thus, at the scale typical of molecules (of the order of a *nanometre*, that is, a millionth of a millimetre) electromagnetic interactions are the only ones that have a perceptible effect. In other words, electromagnetism is the basis of chemistry, the engine of the *nanoworld*. There are many manifestations of this force in our daily life (in fact, our life *is* electromagnetism): objects have colour, there are foods that we like and foods we do not, our car and mobile phone work… and when we shake somebody's hand, our hands do not blend with each other and we do not fuse with the person we are greeting.

Thus, rooted in the domain of molecules and dominated by electromagnetic interactions, *nanoscience* has emerged as the experimental framework that will shape the relationship between mankind and matter in the 21$^{st}$ century. Two of its derivatives, *nanotechnology* and *bionanotechnology,* are interdisciplinary areas of knowledge used in laboratories to coordinate atoms, inorganic molecules or biomolecules in order to construct higher structures with specific functionalities, just as atoms become arranged in a lattice or the way that living beings assemble simple molecules to synthesize larger and more complex ones. Just like physics was the "star among the sciences" in the first half of the 20$^{th}$ century, and molecular biology the star of its second half, nanotechnology will rule over the century that has just opened. Much remains to be known about the organizing capabilities of nature before it can be accurately mimicked, but there is no doubt that we are on our way: today's nanoscience will be tomorrow's nanotechnology.

Among the *nano-objects* already designed and produced in the labs, perhaps the most promising are carbon nanotubes. These are constructed by folding planes of carbon atoms (connected to each other in a hexagonal lattice reminiscent of honeycombs) to generate three-dimensional arrangements. The 2D network becomes a 3D network. It is like folding a fisherman's net upon itself and at the same time

shrinking its size to a thousand-millionth of the original. This generates a tunnel of nanometric dimensions that can be used to conduct electrical currents or store molecules, among other applications.

The technique that has contributed most to the development of nanotechnology has been so-called near-field microscopy, which includes the "atomic force microscope" and the "scanning tunnelling microscope." These new and revolutionary technologies derive from the *quantum* properties of matter, that is, from the laws and behaviours that rule the world below the nanometre (inhabited by atoms, electrons, atomic nuclei, and so forth). The quantum world is governed by laws different from the ones we take for granted in our Cartesian world: what our reason may dismiss as absurd and nonsensical (for instance, the idea of an object not being in one specific spot, but rather delocalized and with a certain probability of being in any of a number of accessible places) is a perfect description of the organization among and within atoms. In addition to the peculiarities of the quantum world, the new scanning probe microscopy techniques have triggered a technological revolution. They have made possible what scientists had been dreaming about for at least the whole past century: to see not only the molecules… but the atoms! They have been called, deservedly, "the eyes of nanotechnology." But they are also its hands, since these microscopy techniques also allow us to act on the molecules or atoms, to move, manipulate, and arrange them, or even to alter the structures or the networks of electromagnetic interactions in which they are embedded. The new technologies allow us not only to *see the network*, but also to *construct it*.

Over the last fifteen years, we have begun to obtain images of the nanoworld underlying the materials that surround us. Thanks to those images, we have learned, for example, that the organization networks connecting atoms and molecules are not static: they are constantly changing. Matter is a fabric constantly being created and destroyed, like the shroud woven by faithful Penelope. Nature, from its tiniest components, is a perfect network in motion.

Today, we know that the nanoworld is inhabited by natural entities (including the aggregates of atoms and molecules present in crystal structures and surfaces or in molecules in living beings), as well as the artificial "creatures" we are able to recreate and reconstruct (new materials, nanotubes, nanoparticles, and biofunctionalized surfaces). The fascinating landscapes hidden in the nanoworld reveal the textures, wefts and networks within the skin of matter: its surfaces.

Moreover, the manipulation of nano-objects has also enabled us to *write* words and complete texts using atoms and molecules on certain surfaces. This is reminiscent of Russian nesting dolls: a network of words — that of writing — contains another one, that of molecules, which includes that of atoms, which further contains that of electrons. In figure 1 we see an ordered network of molecules on a surface. Each protuberance of this revealing image is a molecule, which arranges itself spontaneously and independently, like dunes in the desert or clouds in the sky.

There is much more in this orderly arrangement than just the aesthetic beauty of its (almost perfect) repetition. If we didn't know they were molecules, we might think this

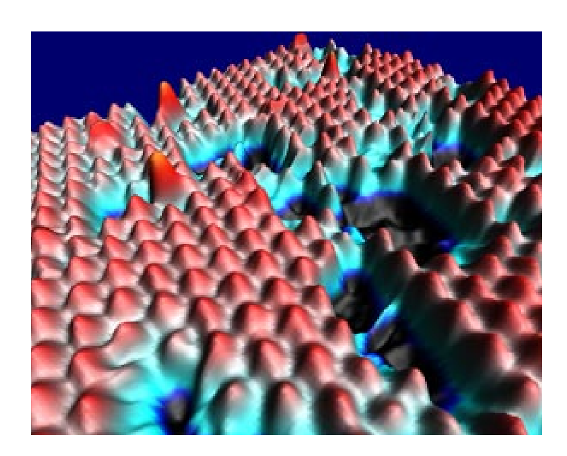


**Figure 1.** Image taken with an STM (scanning tunnelling microscope) used in an ultra-high vacuum. The protuberances are organic molecules called PTCDA, evaporated on a gold surface. (Image courtesy of the ESISNA Research Group, http://www.icmm.csic.es/esisna.)

landscape existed on a much larger spatial scale. It is the first indication of the capacity of groups of elements (and individuals) to organise themselves with no need of supervision, with no purpose or goal, guided solely by the constructive capacity of their interactions.

One of the keys hidden in networks is *absence*: that of nodes that do not exist. New microscopies enable us to understand order and regularity, and also to study disorder. In matter, certain atoms or molecules occasionally stray from the row and the structure loses its periodicity. Then the network is defined by what is missing, by what is not there. This is essential, for example, in semiconductor materials, the foundations of electronics and most of the technological devices around us. As an example, in [fig. 1] one observes that some molecules are not present in the network and the surrounding molecules have moved slightly, influenced by those vacancies. Matter is a network, and it reacts to absences.

## 2. Networks sustaining biological function and the origin of life

The appearance of life marked a qualitative leap in complexity with respect to the interactions of atoms and molecules within the inorganic network of the prebiotic world. Beyond inert groupings resulting from the laws of physics and chemistry, with the origin of life 3,800 million years ago, a type of molecular organization emerged that enabled the existence of *inheritable information,* transmitted from one generation to the next. The beautiful structures resulting from the most fundamental properties of the universe, the four forces, were now able to incorporate and remember modifications, compete for available space, and evolve. That was possible given that molecules appeared that were able to reproduce themselves; that is, to make copies of themselves and generate descendants based on the parent molecule used as a template. This marked a significant, qualitative leap with respect to what matter was able to do prior to that time, when it was a passive subject of the principles of quantum physics and electromagnetic forces. When life began, certain sufficiently complex molecules were able to make copies of themselves, acting both as templates and catalysts for the replication. Something new took place in the history of matter. Especially noteworthy in that process of primordial replication was the fact that errors or mutations were produced (nature never makes exact copies of an original), such that all the descendants were different from each other and also different from the parent molecule. The biodiversity thus generated made it possible for some molecules to adapt better than others to environmental changes, which in

turn would enable them to create more progeny in the subsequent generation. This copy-with-mutation process followed by the selection of the individuals who adapted best is the key to evolution, as Charles Darwin postulated almost 150 years ago. Thus, the origin of life was the origin of information and evolution.

The evolutionary process, once underway, became robust enough not to disappear: it has continued to date, and will carry on as long as life exists on this (or any other) planet. Today, the principal molecules of all living beings are chains or polymers that perform highly specialized functions. Therefore, in all cells, deoxyribonucleic acid (DNA) constitutes the archive of genetic information, the genome. Proteins are responsible for building the structural framework and carry out the main cellular functions, including the catalysis of metabolic reactions performed by those called *enzymes*. Individual metabolic reactions connect to each other to form one of the most complex and essential networks in biology: the metabolic network. The third essential polymer, ribonucleic acid (RNA), is a molecule with a structure similar to that of DNA, and constitutes the intermediate step in the genetic information flow produced in all living beings: DNA→RNA→Protein. However, RNA is far from being only an intermediary molecule. Research over the last three decades has shown that RNA possesses the potential to carry out functions similar to those of DNA (in fact, a large number of known viruses possess an RNA genome) and those typically performed by proteins (there are RNA enzymes, called *ribozymes*, that are essential to all living beings). Thus, RNA is actually the only biomolecule capable of functioning simultaneously as a *genotype* and a *phenotype*, the two sides of the coin of life.

Due to this peculiarity, in addition to its remarkable functional versatility, RNA has been proposed as the molecule that led the transition from inanimate matter to living matter, approximately 3,800 million years ago. That hypothesis, known as the "RNA World" theory, is the most probable based on current knowledge, although it still presents some unsolved problems. In addition, the molecular features of RNA make it a very interesting model for biochemical organization, given that the chain of monomers (called nucleotides, of which there are four types: A, C, G and U) that form each molecule (that is, the genotype) always folds to create certain structures capable of carrying out biological functions (phenotype). It has been shown that there are many chains of RNA able to fold into the same structure. An example of this *degeneration* between the genotype and phenotype are the numerous twelve-nucleotide molecules able to form an identical structure with a hairpin-like shape, including some with quite different sequences, such as AGCCUACUGGCU, UUGUCACGACAA, or CCCGAUAACGGG. In the three cases mentioned in this example, the first four nucleotides connect to the last four (thanks to the interactions between complementary nucleotides: A with U and G with C), leaving a sort of bubble in the central region of the molecule that contains four unpaired nucleotides: this arrangement originates the "hairpin" we referred to.

In RNA, the processes (also governed by the laws of electromagnetism) leading to the formation of structures from a linear chain of monomers always take place. Therefore, it is possible to make representations of what are called "sequence spaces" and "structure spaces", tracing the networks that connect

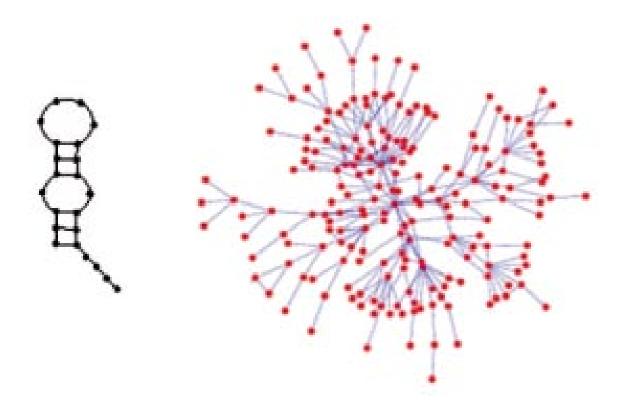


**Figure 2.** A simple RNA structure (left) accompanied by a schematic representation of the corresponding neutral network (right). The red nodes represent sequences with a folded structure of minimal energy, as shown. The links join pairs of nodes differing in a single mutation, that is, two molecules with identical sequences except for one nucleotide (Image by S.C. Manrubia and J. Martín-Buldú).

different molecules with each of the structures compatible with their length. *Neutral networks* are constituted by an astronomically large number of sequences that, in their most stable form, fold into the same secondary structure. In a neutral network each node is occupied by a different RNA, all folding into the same structure, as shown in [fig. 2]. Two molecules are joined by a link if their sequences only differ in one nucleotide; that is, if a sequence can be transformed into the other by means of a single *mutation*. The molecular RNA populations move on these networks, given that all the sequences represented are in principle equivalent as far as they carry out the same molecular function (given that they fold into the same structure).

However, a neutral network is not a homogeneous set of elements. In some areas of the network sequences group together, and there the most robust population of sequences is found: its functionality is less affected by the appearance of mutations. The network is more diluted in other parts of the sequence space. These are evolutionarily conflictive areas, given that any mutation arising in a molecule will destabilize the structure and thus the viability of the population.

Some of the properties of these complex networks are fundamental to understanding how a replication system can maintain itself in the face of frequent perturbations. One of the main difficulties in explaining how the first complex molecules came into being is precisely this: how did they maintain the information while replicating with a high mutation rate, given that it places strong limitations on the length of the evolving sequences. The movement of molecular populations on these vast networks depends on existing pathways between two genetic "locations." Areas that are not continually accessible will never be observed in nature. We are restricted to the small area that made evolution possible, where the process began, before everything became more complex. However, these networks have an interesting characteristic: they percolate in the sequence space. *Percolation* is a phenomenon that gives living systems their enormous capacity to adapt. If we take two different, useful and functional molecular structures at random, the percolation property of neutral networks in the genome space ensures that there is a nearby sequence (only one or very few nucleotides away) that could generate both structures. Percolation in sequence space ensures robustness and flexibility. Change is allowed as needed, but continues to produce functional structures in the face of minor mutations.

Neutral networks provided the topological foundation for each of the populations of small molecules that subsequently reacted to form their own chemical interaction networks (e.g., metabolism) or networks that regulated

the expression of the genome being built. Vital organization rests on the most basic structure, on the simple topology of spaces of the possible where what matters are not things (molecules, proteins, cells or individuals) but rather the unexpected and often universal relationships established among them. A deep knowledge about these networks does not explain why evolution made us into social beings. However, it does offer clues for understanding many ubiquitous forms of organisation observed in groups of individuals with much greater inner complexity than a sequence of nucleotides. Examples include ants, birds... and human beings.

### 3. Language, genealogy and inheritance: the construction of social networks

In one of its countless branching events, the evolutionary process had certain multicellular eukaryotes turn into animals, and then some primates developed their brains enormously. Evolution made us human. Nowadays, social beings that we are, when we think of our relational networks we tend to overemphasize the significance of a (contingent) history, family inheritance, our memory. But the behaviour of large groups is ruled by statistical principles, not by personal volition. There are forces among us that pull us toward or away from others, that make us prefer one group to another. At times, our personalities vanish and we seem to have become a group of social insects rather than a society of distinct individuals. Perhaps we are but particles sustaining interactions, photons that interweave their existence to that of others and partake in a relational network encompassing all of mankind, a network whose reach we would recognise were we not this short-sighted. When we define our being in the world by the immediacy of the here and now we narrow our perspective. Our own relational dynamics dictate who is or is not in our neighbouring nodes, and conditions the building of circuits which, from a bird's eye view, traverse all of society. Percolate through it. On certain occasions, the plan of a city is but a surface covered in atoms in which the network is defined by their absence. Just like the nanoworld constructed the chemical universe with the aid of the fundamental forces, a universe that set the principles which allowed the evolution of life and of complex brains, and the latter are the foundation that makes society and culture possible, so we must imagine higher levels of organization that transcend us and in which we are the equivalent of those simple RNA molecules that travel within a boundless space of sequences subjected to the vagaries of evolution.

At the foundation of our social being, of our being trapped within a network, is our cultural and biological baggage. It is an enormous amount of inherited information that links us to each and every other human being in this dense world. We are the children of two individuals of different sexes. One gave us our surname, the other our mitochondria; both passed on their nuclear genes, intimately entwined, and their language. What we brandish as our individuality is in fact the complex articulation of what has been given us, and their expression within an environment that conditions us in a thousand imperceptible ways. We are beings in context, inextricable nodes in the network of humanity.

Our inheritance is visible in various ways including our genealogies. We have two parents,




**Figure 3.** The family tree of Henry II or the social network of his ancestors? Repetitions in genealogy are common not only in small populations (such as aristocracy, which consists of individuals historically bound to marry others in their own class) but in any population as long as we go far back enough in time (Smithsonian Institute).

four grandparents, eight great-grandparents, and so on, in an explosion of individuals that lived in the past and who have bequeathed to us part of their genomes, as shown in the family tree [fig. 3]. This is our local version of the tree of life, the one that eventually links us to fungi, plants, bacteria, and every other living being. The surname or the language that we speak, two features to which we tend to feel overly attached, are but a minute fraction of what we accumulate constructively. If we go back but two hundred years in our family tree, the number of our ancestors increases to about one thousand individuals. Probably all of them contributed to our genome. Only one contributed to our surname.

The situation becomes paradoxical if we continue looking back. A hundred thousand years ago, between ten and a hundred thousand modern humans populated the Earth. Our family tree, then, should show an inexpressible number of individuals: one followed by about fourteen hundred zeroes. But only the humans who existed at that time can be part of the family tree. There is a simple solution to the riddle. As we go back in our tree, the frequency of individuals who are repeated increases: we all know examples of more or less distant relatives who have married among themselves.

This is the source of the repetitions, and also an evident example of how society builds its networks… and how the networks in turn shape society. The similarities among the family trees of any two individuals chosen at random increase as we go back in time. We do not need to go far. Let us picture a population of a thousand individuals in which couplings occur randomly and whose size has remained more or less constant through time. It only takes eighteen generations for the family trees of every individual to be identical, a point in which an ancestral population appears (about 80% of the total) who are the forebears of all of the present individuals. In a population of size $N$ of the above characteristics, it takes an average time of about 1.77 log $N$ generations to find the first common ancestor of two randomly chosen individuals. And the leap from the first common ancestor in two family trees to a full

match happens in about fourteen generations, regardless of population size. This is too short a time to assert that our differences are due to inheritance.

Geographic isolation, much more common in preceding centuries than in our globalized present, has fostered diversity among humans. Those populations that remained isolated the longest have cultural features farther from the average than other populations that have sustained regular exchanges. Linguistic diversity is the clearest example of how the sole factor of geographical barriers that constrain mobility can lead to the emergence of multiple detached communities as far as language is concerned. On the other hand, the effect of such barriers disappears as soon as regular relations are established between two groups that differ in their languages. The more than 500 languages spoken in Papua New Guinea are an example of the first situation; the development of the Creole dialects in the span of a few generations out of a need to establish trade contacts, and the loss of grammatical complexity that it entails, is an instance of the second. Our world has experienced an irreversible transition toward homogeneity with the development of means of transport and the global information network. The population flows, the ease with which we travel long distances, the increasing probability of living in several different places far from each other, and the mingling of cultures involved in all of the above have changed the structure of the cultural and linguistic inheritance process. In the European farming societies of the past few centuries, the typical distance between the original residences of a husband and a wife ranged between 5 and 10 kilometres. At present, this distance is much larger. Worldwide population flows, which do nothing but increase, configure a new social structure. Languages are lost irreparably, and their transmission is no longer ruled by parent-child inheritance, but by a socio-cultural engine that pushes individuals to move in search of a life that may not be better, but is certainly more Westernized. And plugged into the net.

## Quantum communication networks: entanglement and percolation

Antonio Acín

Juan Ignacio Cirac

Maciej Lewenstein

**Quantum communication is based on the phenomenon of entanglement among particles. Entanglement enables two distant particles to become correlated, a technical term meaning they remain joined in a sense. Therefore, when a change takes place in one of the particles, effects are shown in the other. In our macroscopic world, this type of correlation does not exist but in the microscopic world of quantum physics, it has been proven through numerous experiments. It also lies at the root of new applications stemming from Quantum Information Theory, a new scientific discipline which studies how information stored in quantum particles is processed and transmitted.**

**In a quantum network, neighbouring nodes share pairs of related, or entangled, particles. One of our major objectives is to understand how entanglement is propagated throughout the network, such that nodes separated by a great distance are able to share entangled particles.**

**Recently, we established a relation between entanglement propagation in quantum networks and percolation, a common phenomenon in the macroscopic world. Percolation has applications in various fields of physics, chemistry and the material sciences. For example, it explains why fires spread even though there is an imperfect connection among fire foci. Once**

a certain level of connection has been reached, the fire makes use of the high connectivity of the network and spreads, becoming very hard to extinguish.

This also occurs in quantum networks: despite imperfect correlations, once a certain minimum level of connection is reached, entanglement can be propagated throughout the network, which enables very distant particles to share correlated quantum particles.

To date, the phenomenon of quantum percolation has not been studied, given that research has focused entirely on linear connections — the equivalent of point-to-point connections — instead of networks. The greater connectivity of networks is what enables entanglement percolation or propagation over great distances. This new line of research will surely lead to the discovery of many new phenomena.

These findings have practical results: the ability to establish entanglement among very distant nodes in a network is the key to the future of quantum communication. Once two nodes share correlated quantum particles, they benefit from all the advantages predicted by the Quantum Information Theory. They can carry out quantum teleportation protocols, making quantum data transmission possible, and perform secure data transmission via quantum cryptography protocols.

P. 58: Percolation 2. Quantum network.

# Research proposal on co-evolution

Alfonso Valencia

The term co-evolution is often used in a loose way to describe any pair of processes with an apparent similarity that might correspond to the influence of one on the other. It is easy to find examples such as the one in figure 1.

In science and in particular in biology, where the term was coined, co-evolution is an integral part of current evolutionary theory, and as such it has acquired over time a precise meaning. Initially Darwin described a number of detailed observations on the correspondence between characters in species that work together, for example orchids and the insects that collaborate in their pollination (from Darwin's *Origin of Species*: "Thus I can understand, how a flower and a bee might slowly become, either simultaneously or one after the other, modified and adapted in the most perfect manner to each other, by continued preservation of individuals presenting mutual and slightly favourable deviations of structure.").

Indeed biologists have described a significant number of species that co-evolve, including the interaction between parasites and their host species, the relation between predator and prey, and symbiotic relations (see Moya et al., 2008). In some cases they have been even able to pinpoint morphological and behavioural specialized traits developed as a consequence of co-evolution.

The more formal definition of the term co-evolution is usually attributed to Ehrlich and Raven (1964), and the modern definition to Thompson (1994), as the joint evolution of ecologically interacting species in which each one of the species evolves in response to the selection imposed by the other. In these terms co-evolution implies the existence of mutual influence in the form of corresponding selection pressure. This simultaneous influence of one of the species in the evolution of the other is really important; it is the specific characteristic of co-evolution and what makes the difference with respect to other loose — common — definitions. It implies that the type and rate to which mutations are accepted by one of the interacting species is directly influenced by what the other partner species allows. In a co-evolutionary framework co-evolution sets the speed and path of evolution in a concerted way, restricting the many potential evolutionary paths that a given species can take to the ones that are permissible for the collaboration with the partner species, which in a strict sense compromises the landscape of future possibilities of the constrains species.

The situation in real ecological scenarios is often more complex that the one described above for pairs of species. More generally a given species is the result of a complex combination of interactions with a number of other species, which can be considered as a set of co-evolving species. Ultimately when the process of co-evolution involves whole groups of species, as it is impossible to separate their interactions in individual pair-

wise interactions, the process is called “diffuse co-evolution” (Futuyma, 1997; Thompson, 1994).

Diffuse co-evolution is directly related with the “Red Queen Hypothesis” (Van Valen, 1973, 1977), one of the intellectually more attractive subjects in evolutionary ecology. The name is taken from the second chapter of Lewis Carroll’s *Through the Looking Glass*, where Alice is taken by the Red Queen into a fast run that does not seem to move them from the same spot. The explanation of the Red Queen is: “Now, here, you see, it takes all the running you can do to keep in the same place.” In the same way biological objects (e.g. species and others) have to continuously improve their adaptation to the environment to keep the balance with other species that are also continuously improving their own adaptation.

From this scenario it is easy to deduce how mutual influence — co-evolution — is an essential determinant of how the individual species and the ecosystems evolve. Taking the interactions into account moves the analysis of biological systems to a more complex level, beyond the individual consideration of isolated species, and makes it necessary to search for integrated — ecological — evolutionary models.

### Co-evolution at the level of protein networks

Proteins are the main active components of cells and they perform most of the biochemical functions that support life. In a typical human cell a few hundred of thousands of protein variants, many of them with dozen of thousands of copies, work in the cellular context by performing functions that require complex interactions. The network of interactions, that keep cells functioning, is formed by the interactions of each protein variant with an average of other seven proteins, a mounting to millions of functional interactions. The modern molecular technologies are for the first time providing detailed information about this fantastically complex massive network in a new field known as Systems Biology (Hood, 2003; Kitano, 2002; Nurse, 2003; Van Regenmortel, 2004). Thanks to these studies we know now more about the properties of protein networks and in particular we understand that they are organized in space-time compartments, that include low level organizations such molecular machines composed of a few to hundreds of proteins, to physical compartments that define the various semi-autonomous organelles of cells, functional modules such as all proteins processing a compound to produce energy in a metabolic pathway, and temporal compartments, for example the proteins acting cooperatively to produce cell division at a given specific time of the cell cycle. These clusters of interacting proteins in cells seems to be the most satisfactory solution to the organization of a network that has to respond to continuous changes in the external environments (Kastan and Alon, 2005; Kastan *et al.*, 2007; Tamames *et al.*, 2007) [fig. 1].

At this point it is obvious to focus on these organizational clusters as the more obvious subjects of co-evolution, given the intrinsic relation between their components and the existence of selective pressure to keep them working in the context of the corresponding cellular systems. The co-evolutionary view of the molecular interaction network in cells implies the consideration of the different protein complexes as independent but connected evolutionary systems. In this case each one of them will follow differential

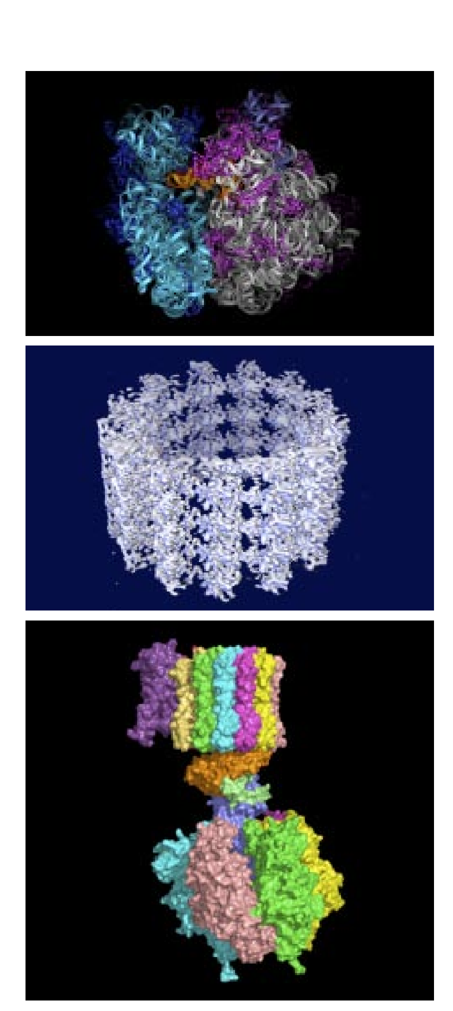


**Figure 1.** Three examples of molecular machines composed by a large number of individual proteins that cooperate, and co-evolve to develop a coherent function in the cell. a) The ribosome responsible for synthesizing new proteins translating the genetic information transported by the mRNA molecules (taken from http://rna.ucsc.edu/rna-center/images); b) microtubules responsible for providing the scaffold for a number of biological processes including neural transmission and cell division (taken from http://www-vis.lbl.gov/Vignettes/KDowning-Microtubules); and c) ATP synthase, a motor-like structure responsible for converting light in chemical energy (taken from http://giantshoulders.files.wordpress.com/2007)

paths resulting for their intrinsic constrains, and their overall equilibrium determines the fate of the complete system. This view assumes the existence of semi-autonomous agents with their own paths, determined by their internal co-evolutionary constraints, in competition with the other agents that conform the system. This radical view places co-evolution at the core of the study of protein networks. Indeed, the understanding of the organization of protein interaction networks will be complete only if the restrictions imposed by the organization of the networks in co-evolving sets are taken into account.

## From the observation of co-evolution to an understanding of its origin

Two general hypotheses have been proposed for explaining the observed similarity of evolutionary histories of interacting proteins. One states that the observed co-evolution of the interacting proteins is a consequence of the similar evolutionary pressures under similar control mechanisms, for example, concerted transcription and regulation of expression, without the need of a physical interaction between the co-evolving proteins.

The alternative hypothesis is that the observed co-evolution is directly related with a process of co-adaptation of the interacting protein sequence and structures. The underlying physical model could be one in which changes that decrease the stability of one protein are compensated by changes in the interacting partner in order to keep the function of the complex, or, more properly expressed, complexes that are functional are selected if deleterious mutations have been properly compensated, an adaptation of the co-varion model proposed by Fitch and Markowitz in the 70’s.

### Extrapolation to other levels

Just looking around there are many other systems that have the capacity of co-evolving, including networks of people (social networks), integral study of human disease taking into account the relation between genetic composition and ambient factors, and material and intellectual products, like the influence between writers, readers and the publishing industry. In this case co-evolution implies (minimally) that there is an actual relation between the changes in the participant units, and they mutually influence their future development. At this level the problem of separating intrinsic and extrinsic factors influencing co-evolution is equally important. That is, to determine the mutual influence — co-evolution — between the actors (people in social networks), from external ones (opinion makers external and common to the components of the social networks), that will influence the system without need of being directly part of the system. Both types of situations will end up producing similar consequences at the level of the phenotype of the system (patterns of co-evolution), but they have different origins and, in an engineering sense, the approach to manipulate them will be entirely different.

Furthermore, as in the case of the species, for any other type of co-evolving system it is important to define the number of components involved and the complexity of their interactions. We can be talking of the minimal scenario of mutual influence between pairs of elements, which can correspond to the classical study of the influence of one composer on another, to a completely diffuse situation, in which all elements in the system influence each other, rendering the system untreatable in practice. There are obviously intermediate scenarios where elements closely related form sets/clusters that present a degree of mutual influence and relation that differs from the one they have with components of other sets. In a more precise sense, quantified in terms of intensity of relations and degrees of relation in clusters in scenarios with multiple overlapping clusters.

Here it is important to bring back the Red Queen hypothesis. In all these systems in which internal relations play a key role and define the landscape of future evolution, the Red Queen hypothesis tells us that internal competition will tend to keep the system apparently unchanged. The different sets/clusters in the system, like the ones described for the protein interaction network, with a strong internal relation and organized in a true co-evolutionary sense, will definitively move in different evolutionary directions, creating visible tensions in the system, a possibility that will certainly have consequences if extrapolated to areas such as society and co-evolving social groups.

### A research proposal

The importance of bringing the subject of co-evolution from the level of species/ecosystems, or any other type of interactions, to the molecular level of proteins and interaction networks, is that it is at this molecular level where it might be feasible to manipulate the system and to perform experiments.

In more detail, at the molecular level it is in principle possible to investigate the causes of co-evolution, discerning the influence of external factors from the one of internal (physical) interactions. It is also at this level where it will be

feasible to manipulate the interactions between proteins to alter the network of interactions by changing the corresponding protein sequences, and therefore to investigate the contribution of different partners in sets of co-evolving proteins and /or to modulate this contribution. Finally, it will also at this level of resolution where it might be feasible to follow the details of molecular evolution by using populations of bacteria cultivated in the laboratory in which the protein network has been artificially manipulated, and directly assess by sequencing the corresponding genes the consequences of the restriction imposed by the co-evolution of systems.

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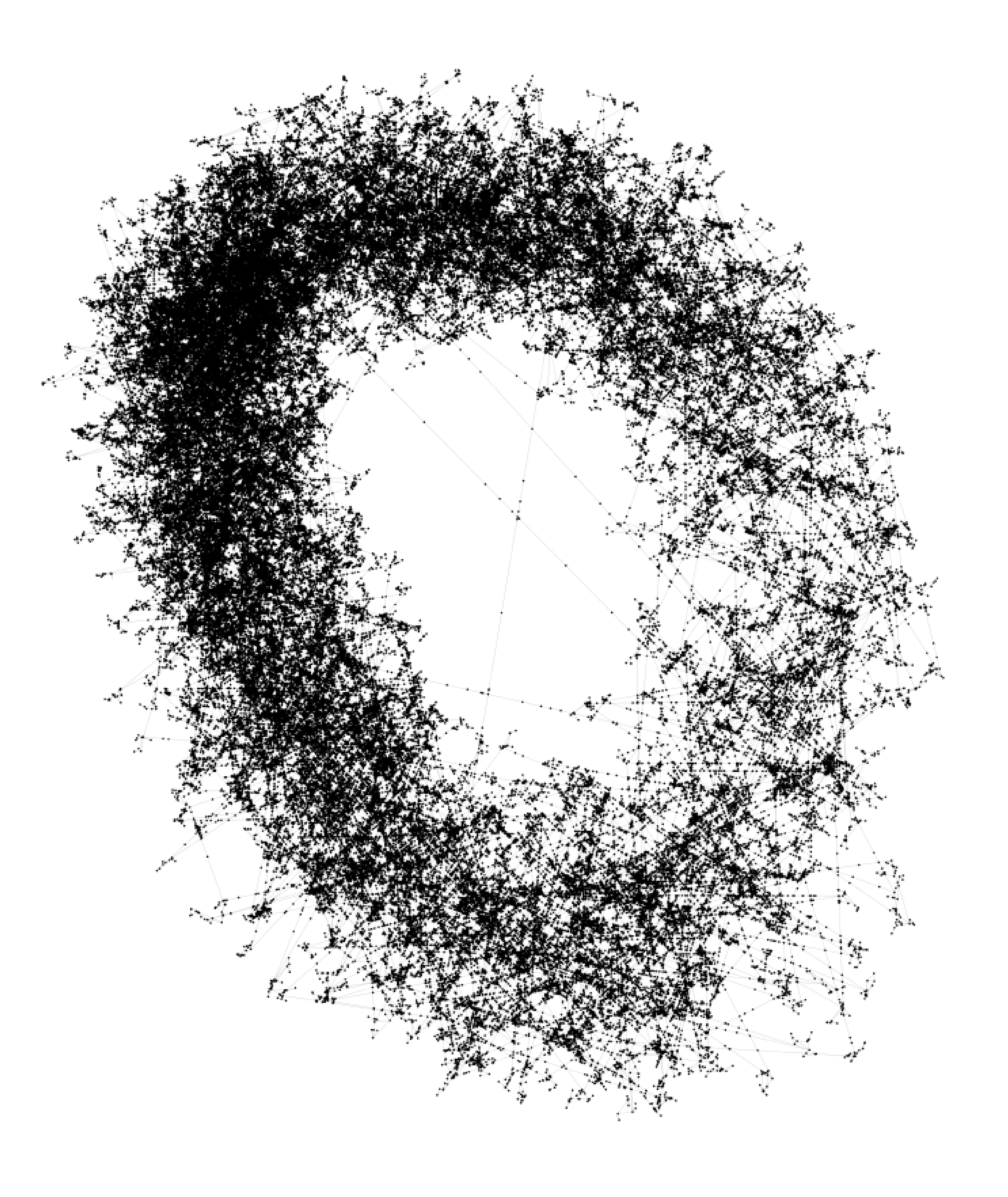
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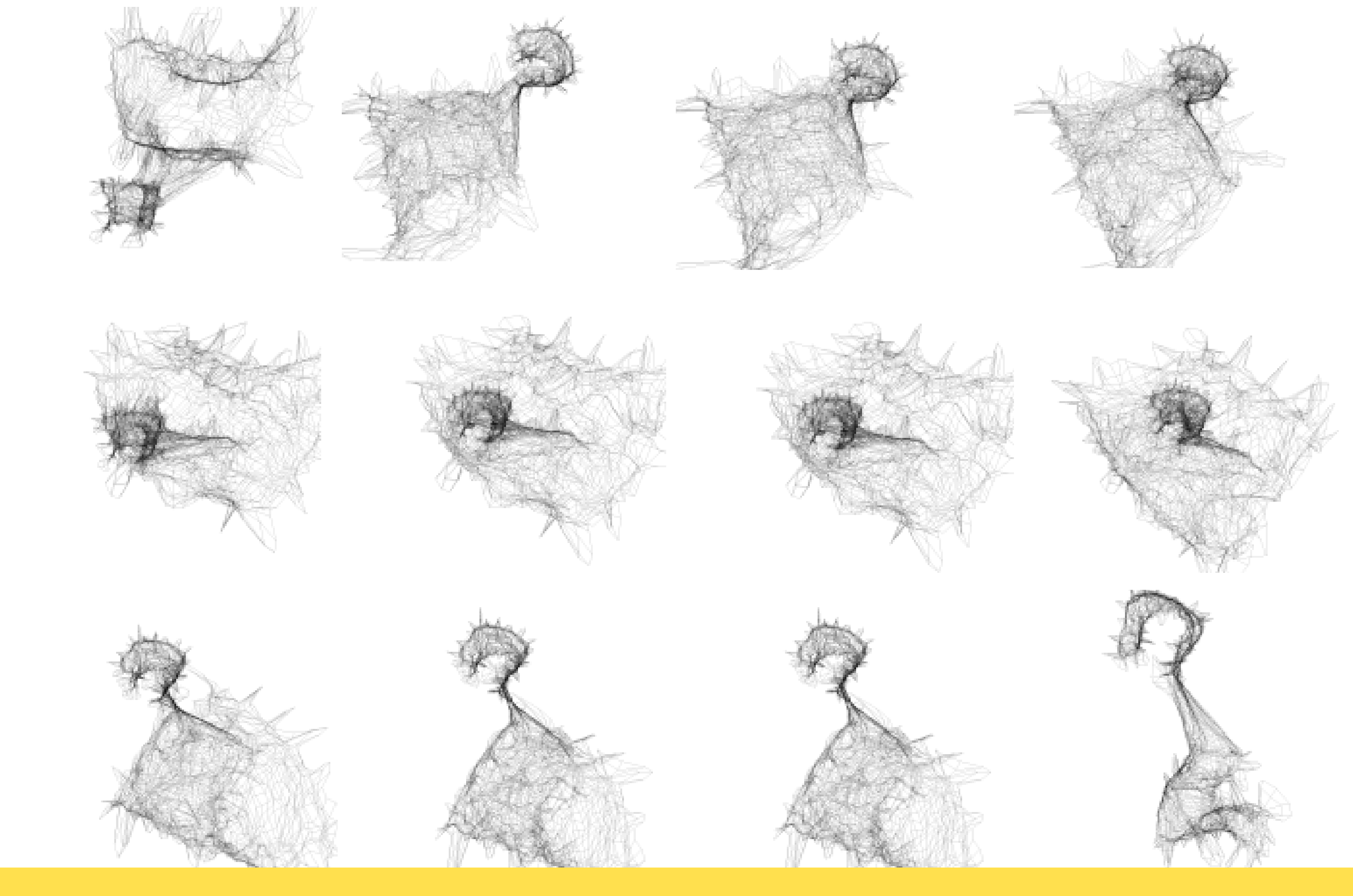
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ÁLVARO CASTRO
***Vacuum Virtual Machine***, 2008

Diverse, changing shapes flow across the screen. What seem at first to be simple, strictly visual and random configurations are actually 3D graphics for visualizing data whose evolution can be seen by the viewer. But those graphics are the external expression, the self-mapping, of a virtual machine. In a manner close to the notion of "artificial intelligence", this device with no physical existence works by constantly developing codes that allow it to modify itself.
This virtual machine dissolves the separation between hardware and software, functioning like a self-organized, non-sequential cell, that is, in a self-creating fashion. The software created by Álvaro Castro constitutes a generative model of complex behaviour through a straightforward interface. Beneath the appearance of membranes and tissues, the user discovers a three-dimensional and synthetic understanding of the self-organization of living systems. A close look at these visual syntheses allows us intuitively to grasp the profound complexity of the dynamic patterns of networks — be they neuronal or social — and their changing architectures. In light of this unceasing cognitive (artificial?) operation, the notion of "intelligence" appears stripped of its air of unintelligibility, mystery and transcendence. Just as the visualization of neurons by Santiago Ramón y Cajal was a milestone — the first time neurons observed themselves (proprioception) — so too, being able to visualize the cognitive process of



this virtual machine offers a wealth of clues for redesigning our future notion of “intelligence.” *Vacuum Virtual Machine* offers a new point of view, both for the understanding of bio-computing and for the configuration of an inevitable metaphor/story of the relations beween humans and their synthetic creations — a disturbing point of view. This is a view in which the realms of artificial and biological intelligence can no longer be differentiated according to their behaviour patterns. Their only point of divergence — and this may be strictly provisional — would be the physical entity that hosts them, the combination of carbon molecules on which they operate. This functional convergence opens doors to those forms of mixed intelligence about which science-fiction visionaries have long dreamed: the expansion of biological intelligence networks through artificial means, expanded minds, synthetic exo-brains and transpersonal reasoning that constitute a certain collective intelligence in which humans and their creations can function at the same level.
**A.S.P.**



PABLO ARMESTO
***Sequences 24***, 2005-2008

The patterns that unfold from genetic activity are continuously changing, responding to the circumstances in which each organism is immersed.

Such patterns respond to the nonlinear dynamics of complex systems, and life is just that. Each gene behaves like a node that can be activated (*on*) or deactivated (*off*), operating like a binary switch responding to the specific signals it receives while at the same time being dependent on the activity of the other genes, which also act as nodes regulated by external signals. In other words, genes do not simply act but instead are activated. Biologists use the term "gene expression patterns." In this way biological forms are not determined by a genetic design but are instead the emergent properties of a complex epigenetic network of metabolic processes. Genes contribute only the initial conditions to determine the type of dynamics that will appear in a given species.

Today we know that natural selection occurs not only in individual genes but also in the self-organization patterns of organisms. That is, natural selection does not choose individual genes — there are no selfish genes — but rather the continuity of the life cycle of organisms. We no longer understand life as a form of predetermined genetic destiny but instead as a system of



networks, which constitute the authentic basic patterns of life. As biologist Harold Morowitz says, “There is profound network logic in the development of the genetic code.”
However, life transcends mere organisms. Life is the fabric of interactions that take place at different scales of space — from planetary to atomic dimensions — and time — from nanoseconds to billions of years. It is a great fabric in which we experience illusions of individuality, projections perhaps of an outmoded determinist vision. Genes “jump” from one organism to another — they always have and they always will. Consequently, the true tree of life is actually more like a thick, tangled bush where branches cross in a medley of ramifications and fusions.

The concept of the individual is increasingly difficult to define from a genetic perspective. It is closer to a physical perspective. The individual, understood as a node, is a dissipative structure, as Nobel Laureate Ilya Prigogine defined it.
**M.S.**



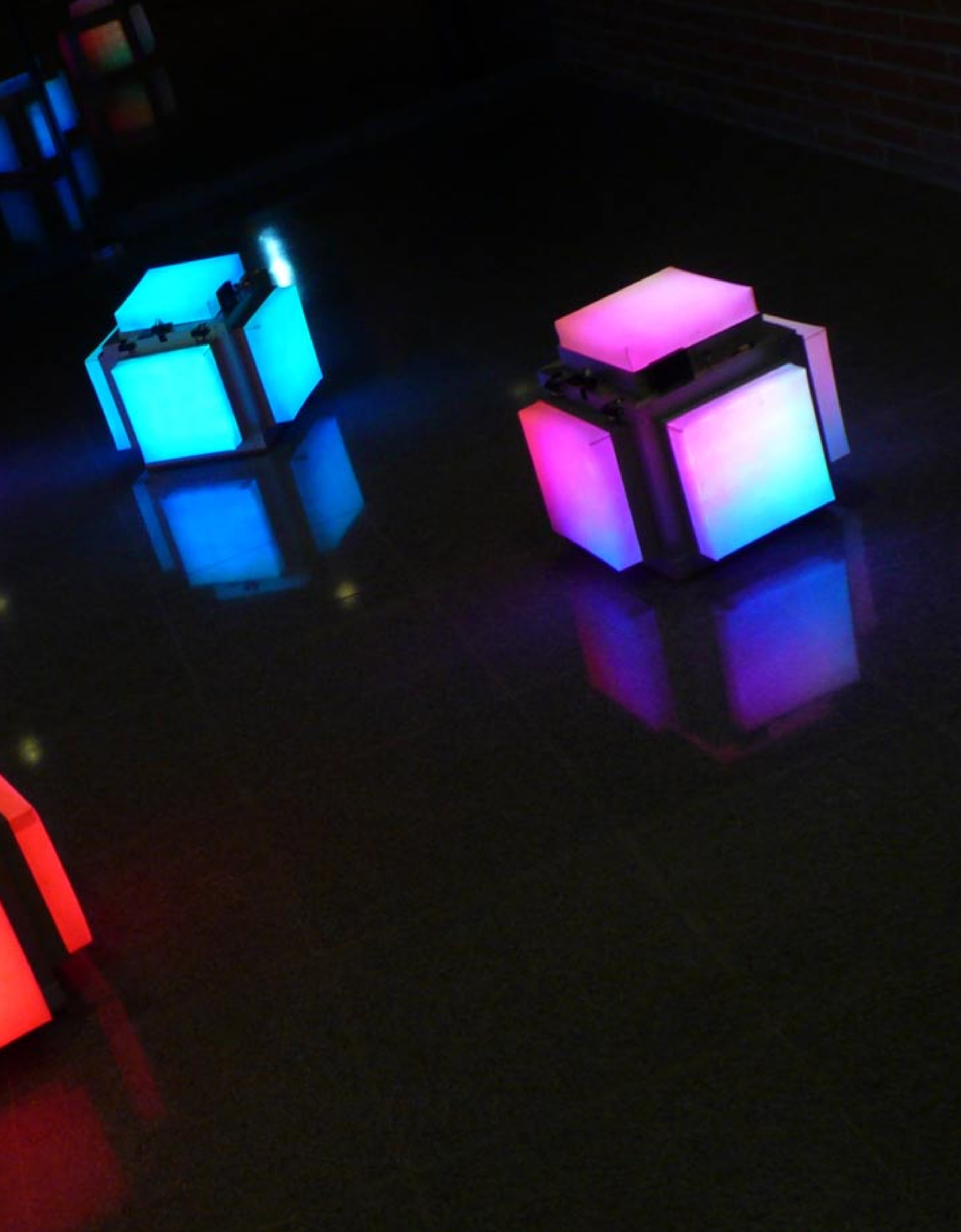
RAQUEL PARICIO AND J. MANUEL MORENO
***POEtic-Cubes***, 2007-2008

I am in the dark space, and silence. In the background I can see a luminous mass of intense colours. It is the mother cell. I head towards her and then the process of cellular self-replication unfolds. New cells are born from the original nucleus, each adopting the same colour code, the same genetic code, as the first cell. Through a complex process, guided by my presence in the presence of other users, they will move to form an organism, an entity that will have a function, a behaviour, something in front of it, something behind it, a shape in space. With my movements, I shape that form, which has just surrounded me, to make me its centre. I move to the right and the organism is shaped with my body. I lean at any angle, I move an arm, or a leg, and the shape adapts itself to my movements. New sculptural shapes and colour mutations follow as a result of the cross, of the interaction among users and among the autonomous entities themselves. I try to move a cell with my hands, which then transmits the information to those adjacent to it, acting from a distance, as if I were sliding through an un-formed mass or liquid where the particles closest to me transmitted my strength, my desire, to every other cell, moving them away from my centre of gravity. This way, moving me and that liquid, floating space, the organism forms its appearance adapting itself to its environment, to the movements of all of those who participate in the experience.



When its energy runs out, it returns autonomously to its energy recharging source, and then begins the cycle once more.
This organism exists as the result of cellular cooperation, where each element on its own cannot carry out the work of the group, where each unit is essential to the action and shape of the whole.
Finding out how that spontaneous order occurs, or in other words, how it develops from one cell, is the enigma of life.
The robotic installation *POEtic-Cubes* has been conceived so that this entire developmental process takes place. P.O.E. stands for Phylogenesis, Ontogenesis and Epigenesis — that is, Evolution, Development and Learning, the basic principles of all living beings. Artificial life uses them as a model to solve everyday conflicts or needs, learning from how nature applies its laws to continue evolving. Thus, through a bio-inspired process, we learn from biological laws to apply them to our prosthetic environment, thus enabling the artificial environment we create as an extension of our body to adapt itself to us.
The installation as a complex bio-inspired system proposes the idea of adaptive environments as systems of perception through autonomous systems that manifest the phenomenon of adaptation, emergence and self-organization.
**R.P. & J.M.M.**

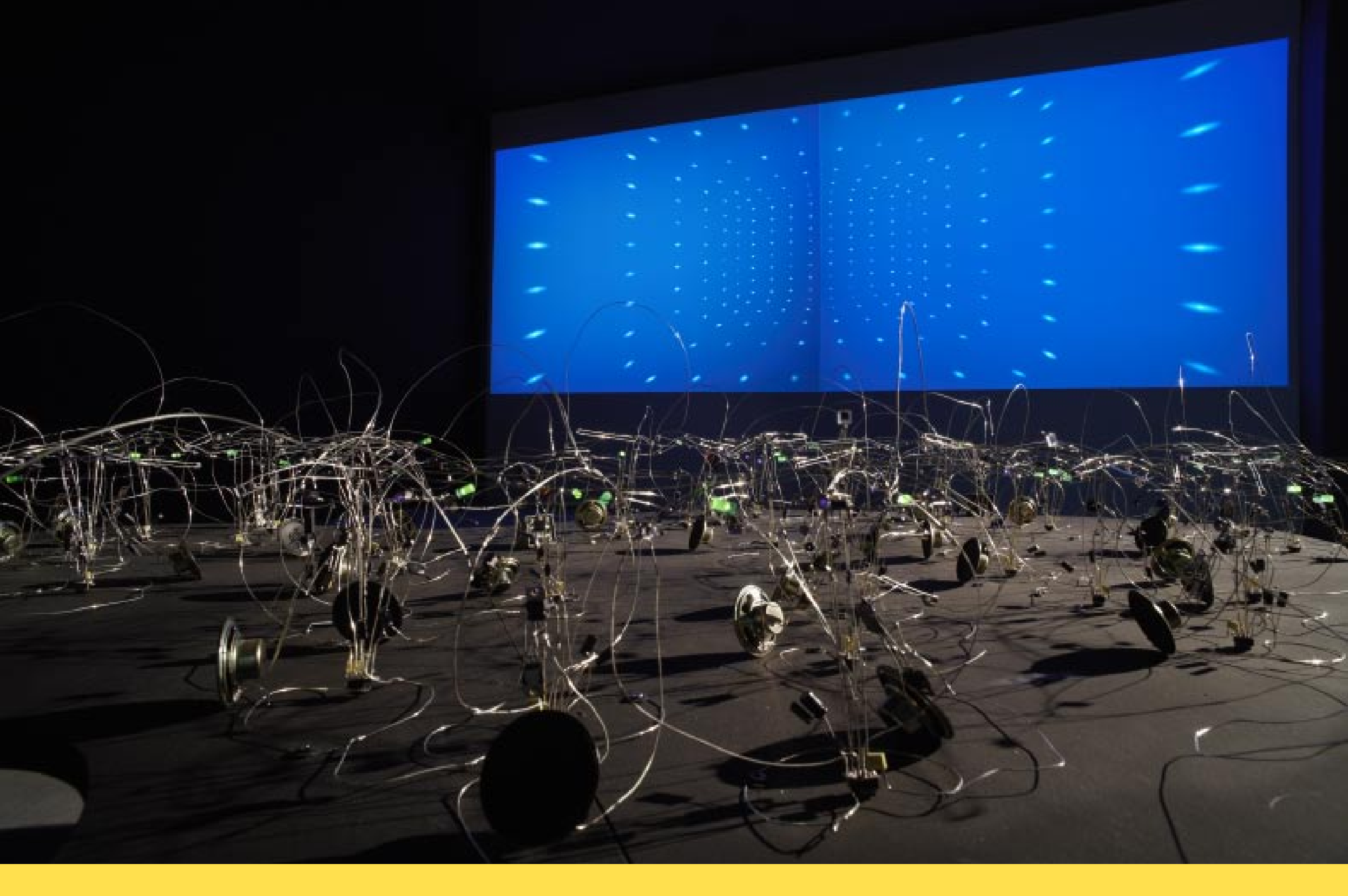






JOSÉ MANUEL BERENGUER
***Luci. With No Name and No Memory***, 2008

Nature, regardless of the organization or the type of material one considers, is full of oscillators. Everything can be seen as oscillating systems: from energy emissions in the form of radiation, each with its characteristic frequency, to pulsars and planets that spin around the stars; geological systems, like the temperature throughout the history of the earth; and stock exchange systems and prices. Some examples of systems that tend to be self-organizing are: homoeostatic mechanisms in animals, the thousands of cellular genes that regulate each other in the gene expression system, the networks of cells and molecules that determine the immune response, the cells in the bundle of Hiss which regulate the heartbeat, and the millions of neurons in the nervous system which provide the material basis for mental activity, learning, and thought itself.
Self-organization also takes place in some groups of fireflies. The male firefly emits an intermittent light signal to which the female responds if the pattern of the intermittence is sexy enough for her. In some groups, the frequencies of the light emissions tend to become similar until, later on, they are all the same. This is a fascinating biological oscillator, able to produce an endless number of aesthetic experiences: whole ponds, trees, and mangroves inhabited by huge groups of these insects end up emitting intermittent green light into the jungle night. Each insect's independent oscillators change after an adaptation process.



The group begins by producing a certain number of chaotic pulsing patterns determined by the independent pulsing frequencies of each insect, to end up joining in a sole intermittent rhythm. They become synchronized.
Fascinated by this vision, I wanted to mimic the emerging behaviour of groups of fireflies electronically in an installation. I made the first model in 1994. I had five electronic fireflies. Now the installation has 60 electronic and 128 computational elements. When ambient light is intense, each electronic object pulses independently. The moment the amount of light drops below a certain threshold — when infrared signals can be captured by the receptors of their neighbours — the system tends to stabilize such that extensive areas are created where the objects begin to pulse in synchrony at some point. The computational agents, with no individual name and no memory, mimic that behaviour and project it in a dihedral angle onto the space opposite the electronic objects. From their individual behaviour, Luci is an unexpected emergence.

**J.M.B.**



LABORATORIO DE LUZ
***Light Modulator 3.0***, 2006-2008

> A uniquely human characteristic is that all the functional apparatuses of a human can never be sated; they are always eager for new impressions after each new perception. This explains the permanent need to carry out new experiments. **Moholy-Nagy**

In terms of kinetic relations of projected light, *Light Modulator 3.0* (2008)[1] explores possibilities in connection with various relations and behaviours between light and sound based on the sound actions carried out by users; the relations of light-space-time/reflections-shadow-movement used in Moholy-Nagy's original Modulator are expanded now with the incorporation of sound, in search of new space-time relations which include the challenge of building a network of relations in an empty space.
The installation is presented as an empty stage setting, waiting for speech. When someone speaks, the microphones attract theatrical lighting. However, the behaviour of the lights in relation to speech, sound, and music leads to unexpected games, and various roles and attitudes taken by light. At times it is quick and intense, but at others, it is hesitant and shyly turns to this microphone or that. It is a social physics of actions and reactions where the illumination desired by all the spectators-actors is not always achieved. Between the microphones, which act as a sensor layer, and three spotlights robotized via DMX, there is specific software coded in C++ — as a synapses layer — to generate



a semi-autonomous interactive light environment where the movement of the light is given as a response or a starting layer. This network of relations is used as an audio patch for feedback, made in Max/MSP, to generate real-time sound based on entry data. There are fixed platforms and variable flows — points, nodes or agents — that manage the structure of the relations. The Modulator, as a complex spatial machine, includes the visualization of the "possibilities" generated (potential events); like a valuation sphere, it retains the routes, registers what happened in graphic representations as a reciprocal agency between the system and any spectator-actor who, after a time, approaches to "find out more" about the mechanism. Light machines, microphones, algorithms and microprocessors designate the specificity of a foreseeable, technical evolution, only altered by the interventions of spectators-actors through the microphones, who introduce into the *Light Modulator 3.0* system a break in the machinelike routine based on connections or links (joining them all to each other, linear, predetermined...) that generate a "network", a praxis that generates heterogeneity; an imaginary network, always open in all directions, procedural in nature, that does not seek to evaluate a possible end (a competitive adaptation to the environment) as an image of uncontrolled technical development, given that *Light Modulator 3.0* works originally as a system that, given the absence of intervention, could not avoid repetition, repose, or chaos.

**L.L.**

1 This is a revision of a prior version, 2.0 (2006) [http://www.upv.es/laboluz/modulador/]

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## Networks, the vital principle

The genetic code of this article: sequence in time.
Typographies Avenir medium and **Avenir black**: text by Diego Rasskin-Gutman.
Typographies **MERCURY TEXT SEMIBOLD** and MERCURY TEXT ROMAN: text by Ángela Delgado.
Sequence in space: as shown by the formatting. The rule or imitation is the coherence of the text.

**In the early 20th century, modern biology experienced a series of great discoveries; the theory of evolution was included in textbooks, Mendelian genetics had been rediscovered, and cellular theory provided a coherent foundation to the substrate from which living beings are made. Many of the ideas and concepts of this time rested on the intuition of the researcher who, despite a lack of knowledge, was eager to probe and discover new horizons. The nature of the phenomenon of life was the subject of scientific, metaphysical and religious debate. Answering the question "What is life?" was a task that seemed increasingly possible as a succession of discoveries took place. Two opposing theses dominated this debate, offering two fundamentally different answers to the "issue of life." Vitalists supported the existence of a substance or some other indeterminate source of the vital phenomenon, one completely unrelated to the subject matter of physics and chemistry, the *élan vital* of Henri Bergson. Mechanists, on the other hand, were scientists convinced that biological complexity could be reduced to the physical-chemical study of its components. The debate dwindled gradually over the course of the 20th century. Molecular biology has taken on the task of ridding the inside of cells of all its mysteries, and has been unravelling the biochemical components that place the phenomenon of life in the domain of natural phenomena. Mechanicism has won the battle. Yet, any biologist would admit that living organisms have a structure and function that cannot be reduced to or fully accounted for in molecular terms. This singular structure of the vital phenomenon is its organization, the interconnections between cell components.**

Networks, interconnections, relationships established between the parts of a system. Events take place, possible "elective affinities" in the words of the great German poet, the result of the synchronic and diachronic repetition of these relationships.

**TO INDIVIDUATE THE PARTS, THERE IS MORE INDIVIDUALITY WITHIN A CONTEXT OF SIMILAR INDIVIDUALITIES. HOW CAN AN AFFINITY BE RECOGNISED IF NOT THROUGH THE ESTABLISHMENT OF RELATIONSHIPS? NETWORKS PROVIDE AN**

IDENTITY TO THE PARTS OF THE SYSTEM. WE ARE BUILT, LIFE IS BUILT, ORGANIZED AND SELECTED IN THE RHYTHMS OF THE SYSTEM'S RELATIONSHIPS.

How can we not see life, this phenomenon that drives us to pursue knowledge and know each other, as a web of networks? Networks. Networks of networks. Meta-networks. The world is defined by facts rather than things — this time our motto comes from the Vienna of positivism — and facts are what happens, what takes place and what occurs. In the language of science, which may always seem cryptic and needlessly defiant, it is not patterns that make the machinery of the vital phenomena run its endless course. Come to think of it, it is a true perpetual motion machine. Life as a process whose motion started billions of years ago and is still ongoing. All of it thanks to networks.

BUT NETWORKS ARE NOT ORGANIZED MATTER; THEY ARE BUT A PULSE, A MESSAGE, DIFFERENCES IN ENERGY POTENTIALS, INFORMATION BITS, A SERIES OF FUNCTIONS. THEY ARE THE LIGHTS AND SHADOWS THAT RHYTHMICALLY DRAW THE VARIOUS ROUTES IN TIME AND SPACE THAT A SYSTEM CAN FOLLOW. YES, THEY ARE PART OF THE VITAL PHENOMENON, BUT WOULD THERE BE INFINITE NETWORKS IF THEY WERE NOT LIMITED BY PATTERNS OR MATTER? NETWORKS ARE TRAPPED IN THE MATERIAL PATTERNS OF NATURAL FORMS, THOSE PATTERNS THAT HAVE BEEN RECOGNIZED AS THE PARTS OF A SYSTEM. OUR BELIEFS AND SOCIAL NETWORKS ARE RESTRICTED IN THE WAYS IN WHICH INDIVIDUALS ARE ORGANIZED WITHIN A SOCIETY, OR IN THE WAY IN WHICH WE DEFINE INDIVIDUALITY. WE COULD INCORPORATE TO OUR BELIEFS EACH OF THE ANIMALS IN NATURE AND WE WOULD HAVE A NETWORK OF THE SPIRITUAL WORLD WITH A COSMOGONY DIFFERENT FROM MONOTHEISM.

**The notion that networks have no structure could be challenged, and depends on the level of biological organization of which we speak. A network of interaction among genes is an information transfer network, but a network of interacting cells is a properly differentiated structure, and the network of the circulatory system, or neural networks, or the connectivity networks in the skeletons of vertebrates all present a defined structure that mediate their functionality.**

IN THE DEFINITION WE ARE CONSTRUCTING OF HOW NETWORKS ARE STRUCTURED BY THE DYNAMICS THAT THEY CAN GENERATE, THE OBJECT (OR INDIVIDUALITY) THAT GENERATES THE NETWORK IS IN TURN INFLUENCED BY IT, EVEN IN THE CASE OF CELLULAR INTERACTIONS. HOWEVER, AN ORGANISM IS AN OPEN SYSTEM SINCE ITS INCEPTION, SO IF ONLY TO CONSIDER THE DEGREE OF COMPLEXITY IN WHICH WE OPERATE, WE SHOULD ALSO MENTION THE ROLE PLAYED BY THE FLUCTUATIONS AND THE NOISE OF THE ENVIRONMENT (PHYSICAL, CHEMICAL AND SPATIAL) IN WHICH THESE INTERACTIONS TAKE PLACE.

Every organism, from bacteria to animals, including seaweed, fungi and plants, have clearly delimited parts composed by highly specific chemical entities known to all of us: carbohydrates, fats, proteins, DNA, RNA, and hundreds of minerals and other special molecules that are repeated over and over, that are being built constantly within the living unit par excellence: the cell. These parts and these compounds are organizational levels of organisms. They are modules with a specific structure and function which derive from the interaction of those components. They are networks. And when an interactive network pursues a behaviour defined by properties generated by itself in a process that we define as self-organizational, this gives rise to the phenomenon of stability, of repetition, of circularity, and of behaviours that recur with alarming precision.

**YES, THAT IS THE TYPE OF NETWORKS THAT HAVE DEVELOPED FROM THAT ORGANIZATION. PRECISION IS PERPETUATED; IN FACT, THE METABOLISM OF ORGANISMS HAS BEEN STUDIED MAINLY BASED ON MODEL ORGANISMS, SOME AS ELEMENTARY AS THE *ESCHERICHIA COLI* BACTERIA. THESE NATURAL NETWORKS THAT EXIST AT THE MOLECULAR AND CELLULAR LEVEL ARE PRACTICALLY UNIVERSAL: IF NOT, HOW COULD WE EXPLAIN THE BEHAVIOUR OF VIRUSES, ABLE TO WEAVE THEMSELVES INTO THE "NETWORK OF CELLULAR INFORMATION", ABLE TO CARRY OUT TRANS-SPECIES INFECTIONS? A KNOWLEDGE OF THE STRUCTURE OF THE NETWORKS ("KREBS CYCLE", "RIBOSOMAL TRANSCRIPTION") ACTING AT THAT MOLECULAR AND CELLULAR SCALE, ALLOWS US TO MAKE USE OF ITS FUNCTIONAL STABILITY. THAT IS THE CASE OF GENETIC CONTROL IN CERTAIN SPECIES TO GENERATE POPULATIONS WITH OPTIMAL PERFORMANCE.**

A cell, through a process called *mitosis*, divides into two cells. The elements present in the original cell are duplicated almost perfectly and where there was one, now there are two. What has happened? The networks present in the cell also had to divide. And the processes they generate now function independently in each cell.

**TO A CERTAIN EXTENT, THE ACT OF WATCHING A CELL DIVIDE AROUSES A PERPLEXITY SIMILAR TO THAT CAUSED WHEN A MATHEMATICAL OBJECT CALLED A *MOEBIUS STRIP* IS CUT IN HALF: THE STRIP DOES NOT SPLIT INTO TWO PARTS. ACTUALLY, THOUGH CUT IN HALF, IT IS STILL A WHOLE; EVERYTHING DEPENDS ON THE TOPOLOGY OF THE EVENT. THAT, HOWEVER, IS WITHOUT DOUBT A QUALITATIVE LEAP, GIVEN THAT WE MOVE FROM WHAT WERE SYSTEMS OF NETWORKS WITH LIMITED, RELATIVELY REDUCED ELEMENTS TO OTHERS. THE LATTER ARE MORE COMPLEX, CHANGE OVER TIME, AND REQUIRE SYNCHRONIZATION, A COUPLING: CELLS AND CELLS UNDERGOING DIVISION, OR WOULD IT BE BETTER TO SAY, *UNDERGOING***

*MULTIPLICATION*, NEED COOPERATION AMONG THE PARTS. PERHAPS WE SHOULD START TO CHANGE OUR LANGUAGE, WHICH TO DATE HAS BEEN DESCRIPTIVE, AND UNDERSTAND NATURE AS EVENTS THAT ARE SYNCHRONIZED, THAT ADD UP, THAT MULTIPLY AS THEY INTERACT OVER TIME.

In the life of a multicellular being that has billions of cells, these divisions take place thousands of times. And the result is always the same, with variations that lead to the terminal differentiation of specific cells, such as muscle cells, neurons, lymphocytes, or liver or pancreas cells; networks lead to new networks. Interactions generate interactions. And the result is an amazing exercise of physical-chemical self-organization whose stability stems from a sole origin: the amalgamation of elements and interactions in the form of networks.

RECOGNIZING THAT LIFE IS DYNAMIC, THAT THE CONSTRUCTION OF AN ORGANISM IS A PROCESS THAT TAKES PLACE DURING THE PERIOD OF ITS ONTOGENESIS, ALLOWS US TO APPROACH THE COMPLEXITY OF THE SYSTEM. WHEN CELLULAR CLUSTERS ARE FORMED, LINKS ARE CONSTANTLY CREATED AND DESTROYED, JUST LIKE ON WEB SITES. HOW ARE NETWORKS AFFECTED BY THE ADDITION OF A NEW ELEMENT OR THE DISAPPEARANCE OF ANOTHER, LEAVING AN EMPTY SPACE? NETWORKS ARE IN PERPETUAL EVOLUTION. IN NETWORK STRUCTURES, DURING THE LONG DEVELOPMENT PROCESS, FIRST COME AUTONOMOUS CELLULAR MECHANISMS (DIVISIONS); THEN MORPHOGENETIC MECHANISMS, WHERE CELLS ARE DIFFERENTIATED AND NEW STRUCTURES OR SHAPES ARE GENERATED (FILLING, CONVEX, CONCAVE, GAPS) THAT DETERMINE SEGMENTATION PATTERNS, COMPARTMENTALIZING AREAS AND CREATING LIMITS OR BORDER AREAS; AND FINALLY, DURING THE ONTOGENETIC PROCESS, NEW RULES AND INTERACTIONS EMERGE THAT LEAD TO THE FINAL CONSTRUCTION OF THE ORGANISM. THE ANATOMY OF NETWORKS MUST DETERMINE HOW THEY FUNCTION IN THE END.

In the evolution of species, the study of connections among anatomical parts of the body shows that networks are also present. Cell by cell by cell, they form amazingly complex networks. Bones connecting with bones form the skeletons that underlie our movements. And brain networks, each area clearly morpho-functionally defined, remind us of the modular nature of organic architecture. In plants, it is even more evident. Subscribed to the Fibonacci number, nodes and internodes occur in perfect mathematical relationship, and in each stem, there are bifurcations and the branches will have other branches that will have leaves and flowers. Each element is a structural module that can be ripped off without affecting the living integrity of the plant.

**MANY PLANTS, IRRESPECTIVE OF THEIR EVOLUTIONARY HISTORY, HAVE OPTED TO ORDER THEIR COMPONENTS IN THE SAME WAY, PRODUCING EQUIVALENT MODULES. THE PROBLEM POSED BY NETWORKS AND MODULARITY IN BIOLOGY IS PRECISELY THIS: WHY IS LIFE SO MONOTONOUS, SO RECURRENT? WHY ARE WE ALL SO MUCH ALIKE? LIFE FOLLOWS ITS OWN GENERATIVE DYNAMICS. THE STRONGER OR MORE ROBUST THE LINKS BETWEEN THE INITIAL MECHANISMS PRODUCED IN DEVELOPMENT AND THOSE THAT COME AFTERWARD, THE MORE CONSERVATIVE WILL EVOLUTION BE. EVOLUTIONARY CHANGE CAN BE UNDERSTOOD AS A DISCONNECTION AMONG NETWORKS, WHICH SOME AUTHORS CALL MODULE PARTITIONING OR CONJUNCTION.**

**In effect, it does seem that there is very little complexity among living beings and the great variation or disparity we find may be more a human interpretation than actual variation. If a creature from another plant visited the Earth, it would surely be disappointed to see the apparent uniformity of designs and lack of variation. This stranger would see the forms and functions of this world, and biological diversity, as a series of clear monotonies around the same structural themes.**

IT COULD BE SAID THAT IN BIOLOGY, OUR ROUTE HAS TAKEN A DIRECTION CONTRARY TO THAT OF THE OTHER NATURAL SCIENCES. OBSERVATIONS OF HOW LIFE EVOLVES WERE BASED ON THE COMPUTATION OF VARIABLES, WHERE THE NORM WAS THE DESCRIPTION OF A MERELY CONTINGENT CHANGE (THE ADAPTIVE CHANGE DETERMINED BY THE SURROUNDINGS AND SUBJECT TO THE RESPONSIVE CAPACITIES AND HISTORY OF A SPECIES), AND NOW WE HAVE COME TO DISCOVER THAT LIFE IS STABLE, MONOTONOUS AND REPEATED MODULARLY. WE RECOGNIZE THAT SPECIES MAY NOT BE USEFUL FOR RESPONDING TO ALL QUESTIONS ABOUT VITAL PRINCIPLES, AND THAT LIFE SHARES AN ORGANIZATION AND DYNAMICS. NOW WE NEED SOME SOLID MECHANICIST RULES ABLE TO EXPLAIN NOT ONLY MOLECULAR OR CELLULAR BUT ESPECIALLY FORMAL PHENOMENA. HOW DOES INFORMATION FLOW THROUGH THESE MODULAR SYSTEMS TO GENERATE, FOR EXAMPLE, HIERARCHICAL STRUCTURES THAT ARE BUILT DURING THE ONTOGENETIC PROCESS? A HIERARCHY IMPLIES THE LINKING OF INDIVIDUATIONS, GENERATING PATTERNS THAT LOOK SIMILAR (BIFURCATIONS, RAMIFICATIONS, FRACTALS, SERIES, SPIRAL GROWTHS). THE ARTISTIC EXPRESSION OF THE EXISTENCE OF A NATURAL HIERARCHY IS THE NUMERICAL RELATIONSHIP BETWEEN THE WHOLE AND ITS PARTS. THIS IS TRUE OF THE GOLDEN SECTION, WHEN WE EXPLORE THE DIMENSIONS OF EACH OF THE PARTS, SUCH AS AN ARM, WITH RESPECT TO THE SIZE OF THE WHOLE OR, AS YOU SAID ABOVE, IN THE PHYLOTAXIS OF PLANTS.

In a landmark article published in the 1960s, "The Architecture of Complexity" by Nobel Laureate in Economics Herbert Simon coined the term "quasi-decomposability", a property that provides living systems with the fundamental quality of *evolvability* or the possibility of evolving by changing quasi-independent modules within a system.

**A MODULE'S CONNECTIONS ARE CRUCIAL TO DETERMINE ITS POTENTIAL FOR CHANGE. IN THE TERMINOLOGY OF DEVELOPMENT, IN ADDITION TO THEIR CONNECTIONS, MODULES HAVE A TIME OF ORIGIN. AS A RESULT, IN HETEROCHRONOUS PHENOMENA, THE NETWORK BUILT MOST RECENTLY HAS THE MOST POTENTIAL FOR CHANGE (DISAPPEAR, GENERATE, OR ALTER THE RELATION AMONG THE COMPONENTS OF THE MODULE).**

IN THE PARADOX OF THE WATCHMAKER THAT HERBERT SIMON USES TO ILLUSTRATE THE ARCHITECTURE OF COMPLEXITY, THE VALUE OF MODULAR CONSTRUCTION IS SHOWN. THE WATCHMAKER WHO ASSEMBLES A WATCH BY MODULES WILL FINISH BEFORE A WATCHMAKER WHO DOES SO PIECE BY PIECE. IN THIS ANALOGY OF THE ONTOGENIC MODEL, THE QUASI-INDEPENDENCE OF MODULES IS PRODUCED NOT ONLY IN THEIR FINAL STRUCTURE (NUMBER OF COMPONENTS, TOPOGRAPHY, ETC.), BUT ALSO AT THE TIME THEY ARE MADE. NETWORKS ARE EXPRESSED IN SPACE AND TIME. THEREFORE, QUASI-INDEPENDENCE IS ACHIEVED IF A MODULE THAT IS ALREADY STRUCTURED IS NO LONGER "AFFECTED" AT A POINT IN THE ONTOGENIC PROCESS WHEN THE INCEPTION OF THE FORMATION OF A NEW MODULE OCCURS. WHAT WE HAVE DONE IN THIS ARTICLE PROVES HOW COMPLEX THE INTERACTION BETWEEN SPACE AND TIME IS. THE RESULT IS A PATTERN ON THE SPACE OF PAPER, BUT ITS GENESIS IS A TEMPORAL SERIES OF CONTACTS THAT HAVE INTERWOVEN. IF THE VITAL PRINCIPLE IS THE DYNAMIC OF COMPLEX NETWORKS THAT FOLLOW ONE ANOTHER, THE KEYS ARE THE MAP OF MOVEMENTS MADE BY THE WATCHMAKER IN ASSEMBLING THE WATCH.



**Figure 1**. Self-portrait of Cajal with his collaborator Juan Bartual Moret, in his laboratory in Valencia, circa 1885. Santiago Ramón y Cajal in his laboratory in Valencia. © Estate of Santiago Ramón y Cajal.

# Cajal and neural circuits

Javier DeFelipe

## Introduction

Santiago Ramón y Cajal [fig. 1] was born on 1 May 1852 in Petilla de Aragón, Navarre, Spain, and died in Madrid on 17 October 1934. He studied medicine and was Professor of Anatomy and Histology at the Universities of Valencia, Barcelona and Madrid. He published numerous scientific articles and books of great significance in the field of neuroscience and received the major awards and honorific distinctions of his day, including the Moscow International Prize in 1900, the Helmholtz Gold Medal in 1905, and the Nobel Prize in Physiology or Medicine in 1906, which he shared with Camillo Golgi (1843-1926). He also played a significant role in the development of science and culture in Spain, as shown by the publication of several non-scientific books (e.g. *Cuentos de vacaciones*, Fortanet, Madrid, 1905) and the foundation of two scientific journals: *Revista trimestral de histología normal y patológica,* in 1888, and *Revista trimestral micrográfica,* in 1896 (later named *Trabajos del*

*laboratorio de investigaciones biológicas de la Universidad de Madrid*). He was a pioneer in the development of colour photography: his book *La fotografía de los colores. Fundamentos científicos y reglas prácticas* (Moya, Madrid, 1912) is a masterpiece on the subject. He was the director of several institutions, most notably the *Junta para la Ampliación de Estudios* (Board for Advanced Studies), founded in 1907 to promote science, culture and education in Spain. Cajal was the Board's first president.

An interesting aspect of the history of neuroscience is that, in Cajal's day, drawing was the most common method of describing microscopic images, without the highly developed micro-photography and other technical media commonly found in today's laboratories. In fact, one of the obstacles Cajal had to overcome was convincing his colleagues that his observations were true, as his drawings were his only proof. That difficulty, however, was to become a useful pretext for Cajal to give rein to the artistic expression that, as a boy, he wanted to develop through painting; however, his father prevented it. He spoke about it in an interview in 1900 (Ramón y Cajal, 2007):

> Undoubtedly, only artists devote themselves to science [...]. I realized that if I wanted to make a name for myself as a painter, my hands needed to become precision instruments. I owe what I am today to my boyhood artistic hobbies, which my father opposed fiercely. To date, I must have done over 12,000 drawings. To the layman, they look like strange drawings, with details that measure thousandths of a millimetre, but they reveal the mysterious worlds of the architecture of the brain... Look [Cajal said to the journalist, showing one of his drawings] here I am pursuing a goal of great interest to painters: appreciating line and colour in the brain.

The structure of the nervous system is very complex and the selective staining methods used by Cajal — such as Golgi's method — did not make it possible to visualize all the stained elements in a given region in the same histological preparation and focal plane. That is why illustrating that structure — as well as its possible connections — through micro-photography was a truly difficult, inefficient task. For those reasons, many of Cajal's drawings are compositions that synthesize the complex texture of a particular region of the nervous system. That is actually one of Cajal's major contributions. His artistic talent combined with the interpretation of microscopic images as he distinguished artefacts from real elements and highlighted fundamental structural characteristics through exact copies of images obtained through the microscope. Using drawings to illustrate histological discoveries met with some scepticism. Many of Cajal's drawings were considered by some scientists as "artistic" interpretations, not as fairly accurate copies of the preparations. That is why his studies went unnoticed at first, until other researchers verified the authenticity of his observations. Cajal's drawings are extraordinarily valuable not only as museum pieces but also as faithful copies of histological preparations.

Cajal's research and theories caused a radical shift in the course of the history of neuroscience, making a fundamental contribution to creating the scientific atmosphere needed for the birth of modern neuroscience (DeFelipe, 2002, 2007). Numerous scientists followed Cajal's example,

verifying and building on his theories in almost all the fields of neuroscience. Cajal acquired notoriety principally due to his lively arguments in support of the neuron doctrine and for being the scientist who provided the most data to prove it. This theory, which presents the fundamental principles of the organization and function of the nervous system, states that neurons are the anatomical, physiological, genetic and metabolic units of the nervous system (Shepherd, 1991). Another of Cajal's favourite subjects was the human cerebral cortex (DeFelipe and Jones, 1988), the subject of this article. To give the reader a sense of Cajal's scientific world, a brief description will be offered of the hypotheses under consideration at that time on the organization of the nervous system. We will see that Cajal's studies of the cortical circuits, based on his beautiful, precise drawings, served as the main starting point for the journey into the fantastic, mysterious neural forest that comprises the brain's grey matter, the basis of our "humanity."

## A hypothesis on the organisation of the nervous system

In Cajal's day, the prevailing hypothesis on the organization of the nervous system was the reticular theory, which posited that the elements of the nervous system formed a web-like *continuum* by means of their propagations (dendrites and axons). This theory, later proven wrong, was conceived originally by Joseph von Gerlach (1820-1896). The success of this theory was due partly to the thought that if the nervous system was a continuous, uninterrupted web of propagations, it would be easy to explain how the flow of nervous information passed from one part of the brain to another. The continuity between their propagations would make the flow of information from one nerve cell to another possible. And then, in 1873, Golgi created the *reazione nera* (black reaction) method. For the first time, one could observe all the parts of a nerve cell (the soma, dendrites and axon) in a histological preparation. Neurons were seen to have a highly complex arborization at the axons and dendrites, so complex that if one stained a region of the brain and each of its neurons with its dendrites and axons, the result would be such an extraordinarily dense tangle of somata, axons and dendrites that it would be impossible to analyse it. Another advantage of the Golgi method is that several cells could be stained in a single preparation — albeit only a small number of them — so that individual nerve cells could be studied as well as the possible connections between them. Yet, despite the excellent results of the Golgi staining method, Golgi himself remained the strongest supporter of the reticular theory, proposing that dendrites had open ends but that axon collaterals anastomosized and formed an extensive network, thus suggesting that the nervous system consisted of a *rete nervosa diffusa* (diffuse nervous web), partially in keeping with Gerlach's reticular theory. Golgi always held on to this conviction, which he defended in his lecture when he was awarded the Nobel Prize along with Cajal.

In the first article he published after using the Golgi method, Cajal confirmed Golgi's observation that dendrites had free ends, but also added another, crucial to the neuron doctrine, that this was also the case of axon collaterals, which would then form a "free" arborisation (without anastomosis). He asserted that "each

[nerve cell] is a fully autonomous physiological canton" (Cajal, 1888). Thus, from the beginning Cajal conceived of nerve cells as functional and anatomical units that communicated with each other by means of contact or contiguity, not by continuity. In support of the neuron doctrine, Cajal continued to furnish numerous observations of various parts of the nervous system in different animal species. Between 1888 and 1892 he published over 30 articles, which were summarized in his first review of the structure of the nervous system (Cajal, 1892), clearly formulating the neuron doctrine. The results of these early studies were so decisive that they constituted the core of the classic, influential article in support of the neuron doctrine published by Wilhelm von Waldeyer-Hartz (1836-1921) in 1891 in which he used the term neuron to refer to the nerve cell (Waldeyer, 1891). Cajal summarised his own contributions to the neuron doctrine in several articles and books, particularly in the essay *¿Neuronismo o reticularismo?* (*Neuronism or Reticularism?*) (Cajal, 1933). The introduction of the electronic microscope in the 1950s, along with the development of new methods of preparing nervous tissue for ultra-structural analysis, made it possible to examine the ultra-structure of the synapse to confirm one of the main tenets of the neural doctrine: pre-synaptic and post-synaptic elements are separated physically by a space about 10 to 20 nanometres wide, which is known as the synaptic cleft (see DeFelipe, 2007).

## The law of dynamic polarization

The neuron doctrine involved a radical shift in the conception of how information could flow within an "infinitely fragmented" brain, as opposed to a continuous neural reticulum [fig. 2]. That is, how the nerve impulse travelled from one nerve cell to another across a physical gap was not known. One of the significant offshoots of Cajal's neuron doctrine was the theory of the law of dynamic polarization of nerve cells, which he proposed to explain the transit of nerve impulses through neural circuits. At the time it was believed that the function of dendrites was mainly one of nourishment, and that axons transmitted nerve impulses out of the cell (a generalization based particularly on the logical conduction pattern shown by motor neurons from the spinal cord to skeletal muscles.) In 1889, Cajal proposed that at least in some cases dendrites functioned as current receptors (Cajal 1889), and two years later (Cajal 1891) he attempted to generalize this idea with the law of dynamic polarisation. It was based on the direction taken by impulses in different regions of the nervous system where the anatomical path taken by nerve impulses was obvious, such as the retina and the olfactory bulb (from the outer world to the inner world of the nervous system) [fig. 3]. Thus, he proposed that neurons could be divided into three different functional regions: a receptor apparatus (consisting of the dendrites and the axon), an emitting apparatus (the axon), and a distribution apparatus (the axonal terminal arborizations.) Later on, Cajal realised that the soma does not always intervene directly in the conduction of the impulses, and that sometimes the nervous current goes directly from the dendrites to the axon (Cajal, 1897) [fig. 4]. Consequently, the law of dynamic polarization gave way to the theory of axipetal polarization. These studies had a great influence on the scientists of his age, and the observations and theories of Cajal were essentially proven.

## Cajal and the cerebral cortex

In his autobiographical book *Recuerdos de mi vida* (Recollections of My Life) (Cajal, 1917), Cajal describes how he felt as he commenced his study of the cerebral cortex:

> I felt a very lively curiosity — it was new and fascinating — about the enigmatic organization of the organ of the soul [...]. Knowing the brain — we said to each other in our idealistic enthusiasm — is equivalent to discovering the material route of thought and will, taking the private story of life in its perpetual duel with external energies by surprise.

He was especially fascinated by the human neocortex and the *butterflies of the soul* — as he so beautifully and metaphorically referred to the pyramidal cells [fig. 5] — or to what he often described as "the noble and enigmatic cells of thought", thus suggesting that they represented the main components of the synaptic circuits of the cerebral cortex [fig. 6]. Today we know that pyramidal cells comprise the main source of excitatory cortical synapses and are virtually the only projection cells in the cerebral cortex. That is, the information processed in one area of the cortex exits through pyramidal cell axons to reach other cortical areas or sub-cortical centres. These cells are also key elements in the columnar organisation of the cerebral cortex and in the overall connections of sensory perception, a phenomenon by which the brain simultaneously integrates the information processed in various cortical areas to produce unified, continuous, coherent perception. Dendritic spines [fig. 7] — which were discovered and baptized by Cajal and consist of small dendritic protrusions that are usually thin, ending in a bulb or head (see DeFelipe, 2007) — are a crucial component in the structure and function of pyramidal cells. In fact, dendritic spines comprise the primary post-synaptic element of excitatory synapses in the cerebral cortex. They are also considered fundamental structures in plasticity, learning and memory processes, which explains the huge interest currently in the study of the microanatomy of pyramidal cells — and especially, of dendritic spines.

Cajal believed that cortical architecture was not a fixed structure and that there was a variable histological factor related to mental processes. As we will see, Cajal's contributions to the study of cerebral plasticity and its relation to mental processes were of the highest significance.

## A hypothesis of cerebral gymnastics: plasticity in cerebral circuits

Cajal learned of the Golgi method in 1887 and then began to apply it. After four years of intense research on the structure of the nervous system — he published over 30 articles, in 1892 he felt ready to undertake his first review of the organization of the nervous system (DeFelipe, 2006). In this review (Cajal, 1892) he presented his hypothesis on cerebral gymnastics as a mechanism for multiplying nerve connections and thus improve the brain's capacity. Tanzi (1893) presented a hypothesis similar to Cajal's but it was based on reinforcing already existing connections (that is, without increasing the number of contacts) to improve the efficacy of neural circuits. Tanzi supported the neuron doctrine and therefore believed that the physical separation of the points of contact between two neurons was an obstacle

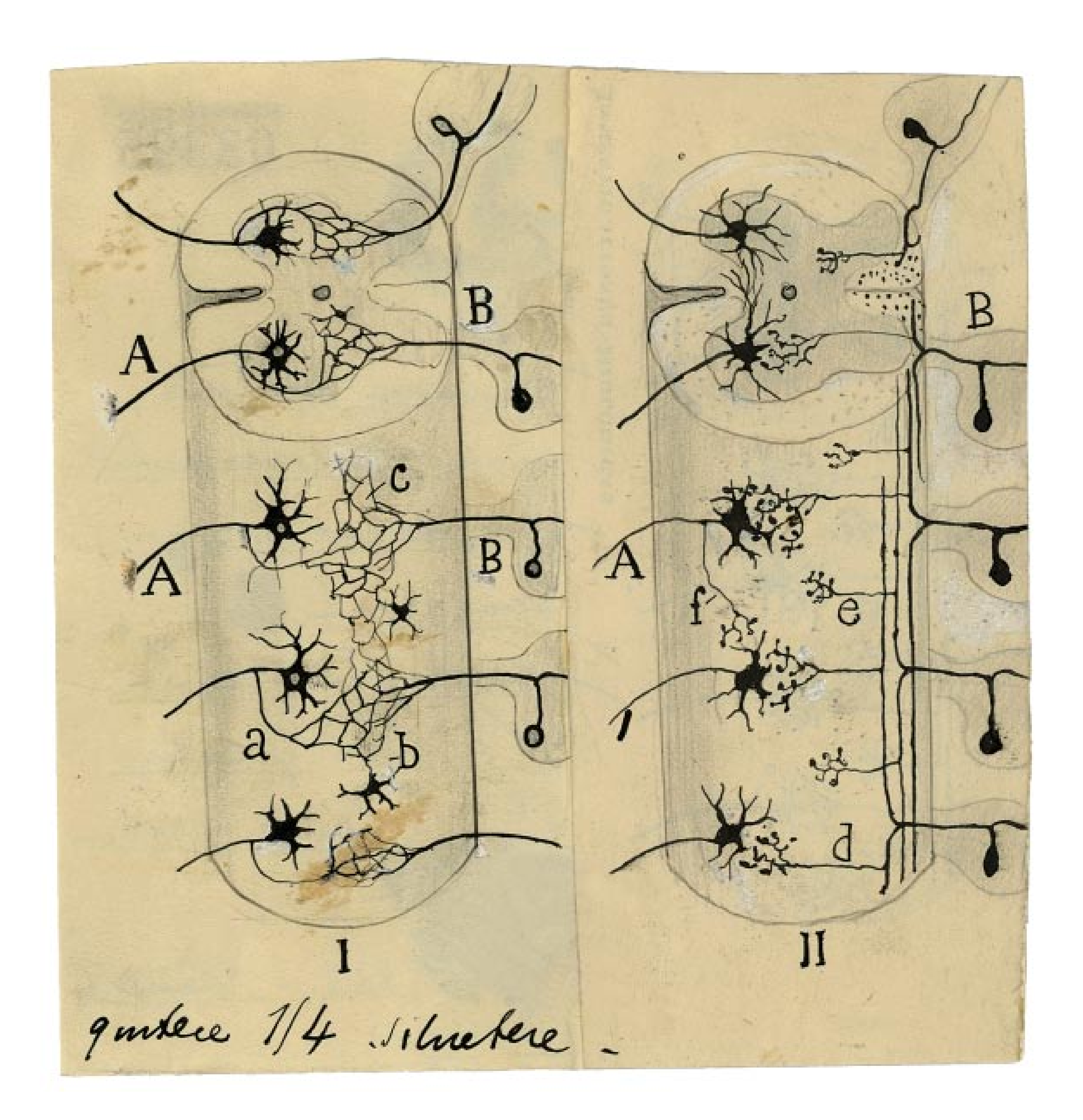



**Figure 2**. Drawing by Cajal illustrating the differences between the neuron doctrine and the reticular theory. "Schematic drawings comparing Golgi's concept on spinal cord sensory-motor communications (I) with the results of my research (II).
*A*, anterior roots; *B*, posterior roots; *a*, motor radicular collateral; *b*, short axon cells that, according to Golgi, take part in network formation; *c*, diffuse interstitial network; *d*, our long collaterals in contact with motor cells; *e*, short collaterals."
This figure was reproduced in *Recuerdos de mi Vida* (Recollections of My Life) (Cajal 1917, figure 9). © Estate of Santiago Ramón y Cajal.

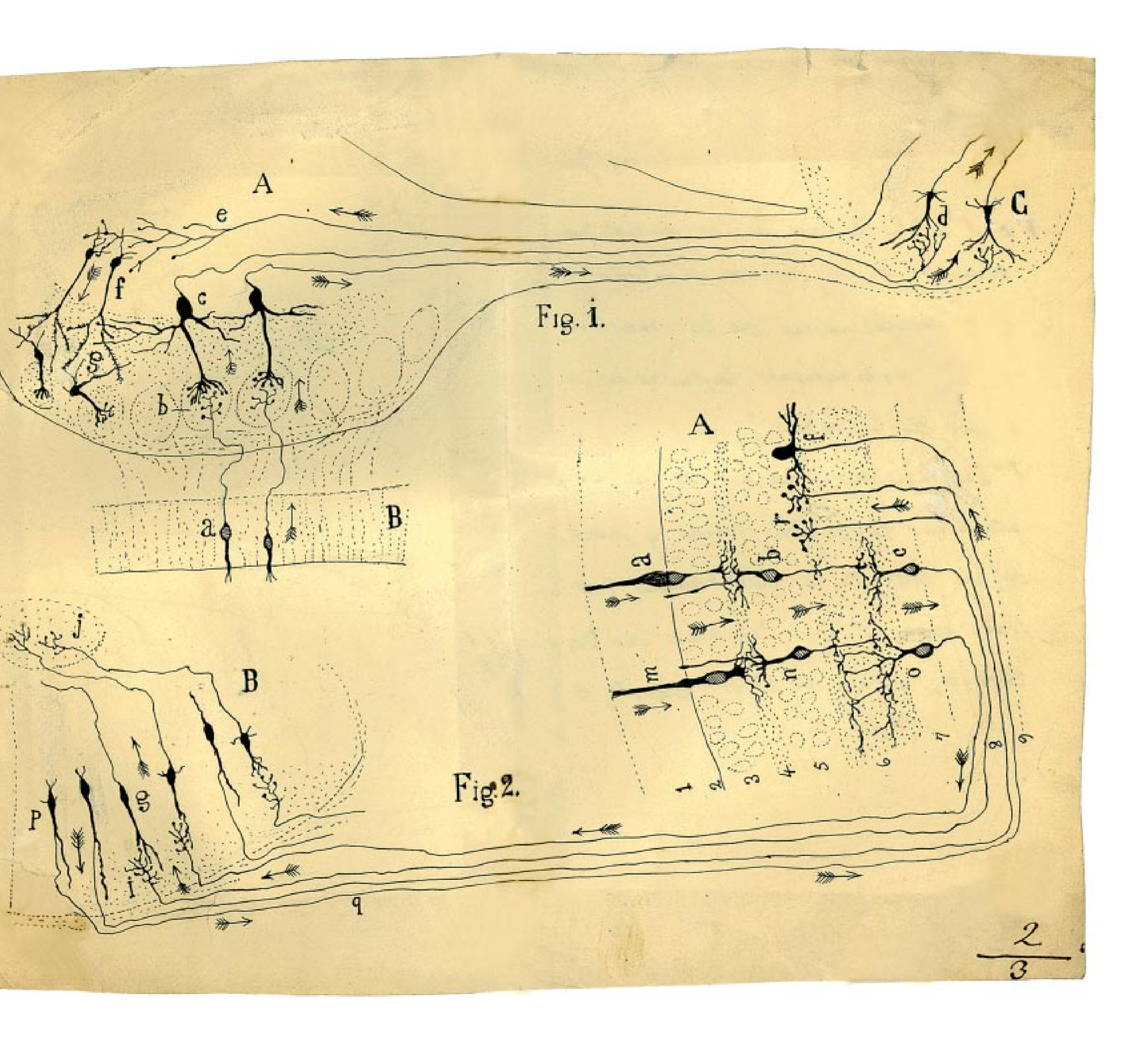
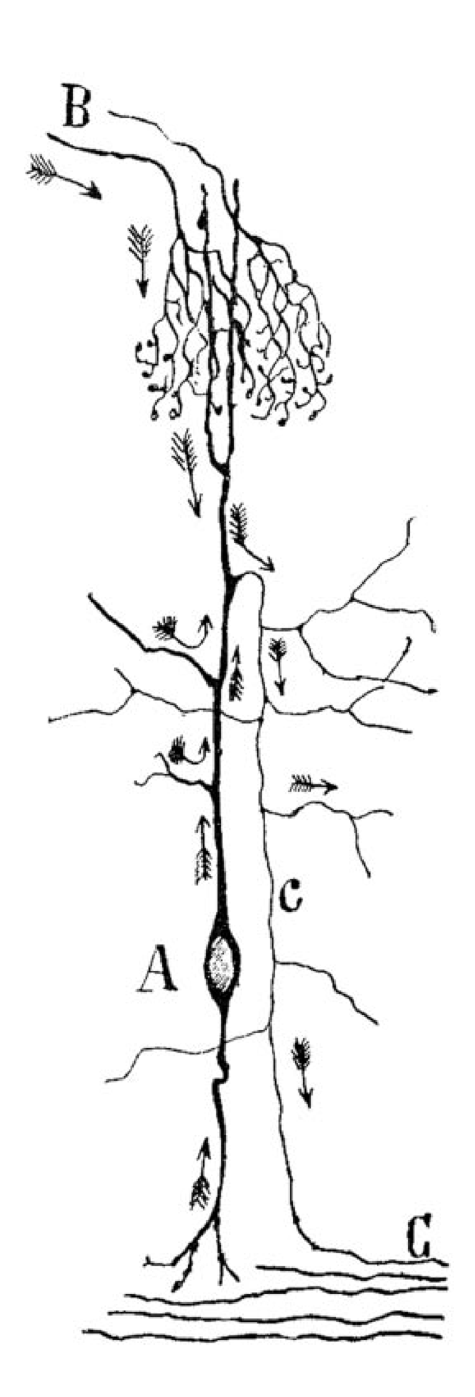



**Figure 3**. Cajal's schematic drawings showing current flow in the visual and olfactory systems.
*Fig. 1*. "Schematic drawing of cellular bifurcations in the olfactory mucous (B), olfactory bulb (A), olfactory tract and lobe (C) of the brain. The arrows indicate direction of current… *a, b, c, d*. Afferent or centripetal pathway of sensory or olfactory stimulus."
*Fig. 2*. "Schematic drawing of light stimuli through the retina (A), optic nerve and optic lobe (B) of birds. *a, b, c*, respectively represent a cone, a bipolar cell and a ganglion cell in the retina: the luminous flux passes through them in that order."
Taken from Cajal, 1891. © Estate of Santiago Ramón y Cajal.



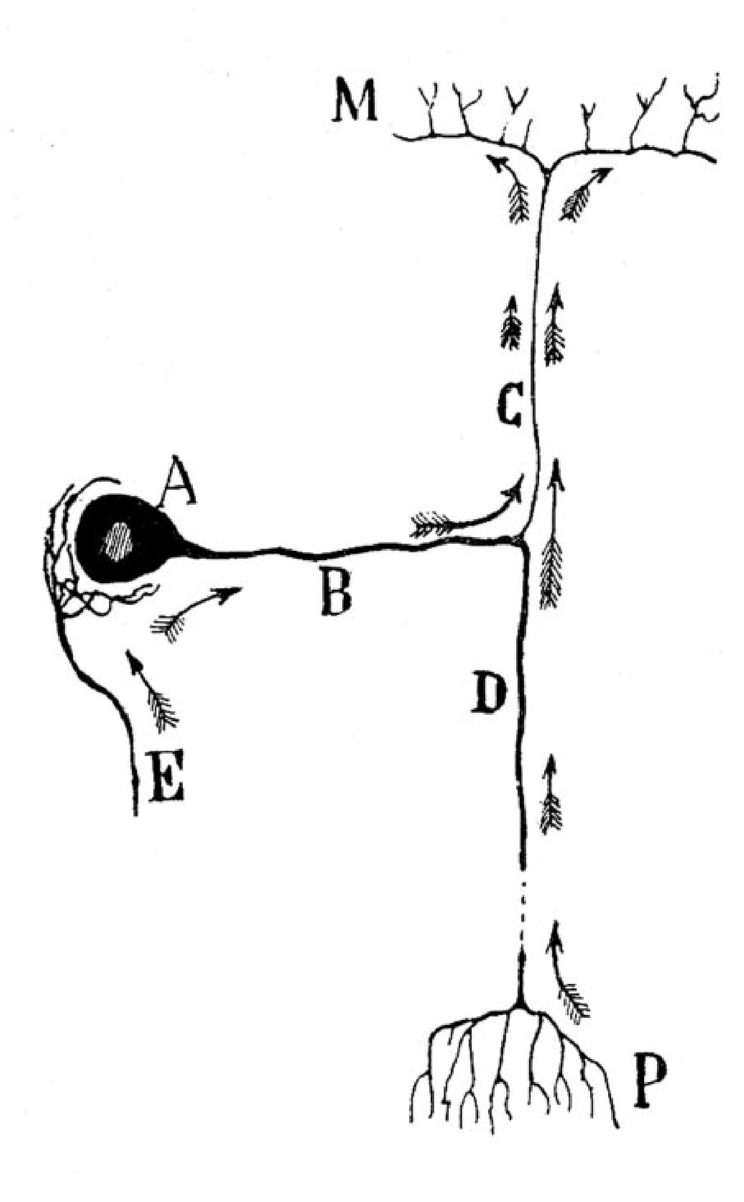
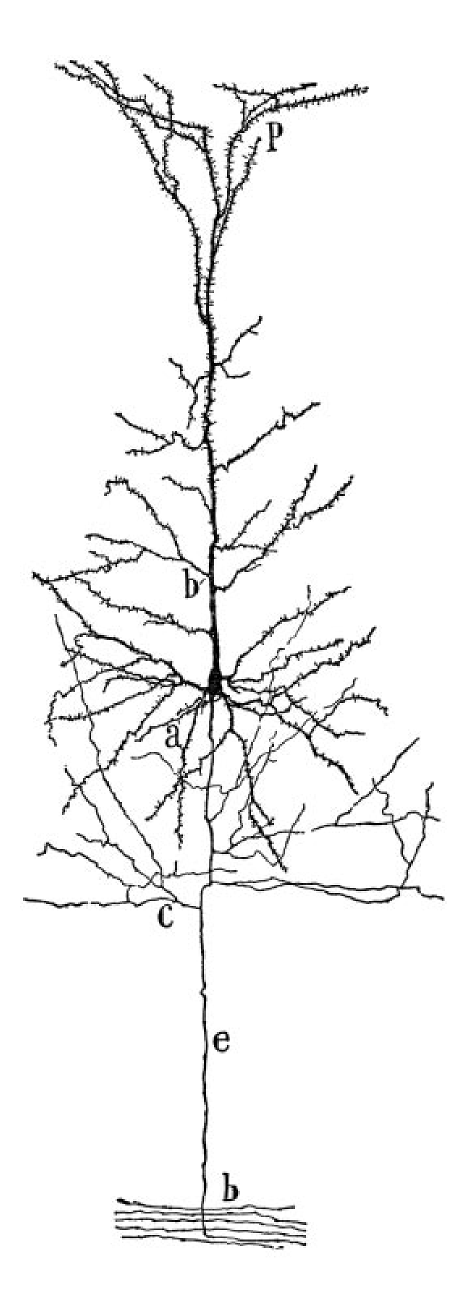




**Figure 4**. Left: “Rod cell in the optic lobe of a sparrow. A, soma; B, fibres from the retina; C, central white matter; c, axon; the arrows indicate direction of currents.” Right: “Schematic drawing of current flow in a mammalian sensory ganglion cell. A, soma; B, stem; D, peripheral or axipetal expansion contributed by currents; C, axon transmitting impulse to spinal cord; E, fibre constituting pericellular arborisation; M, spinal cord.”
Taken from Cajal, 1897 (left, fig. 1; right, fig. 5).



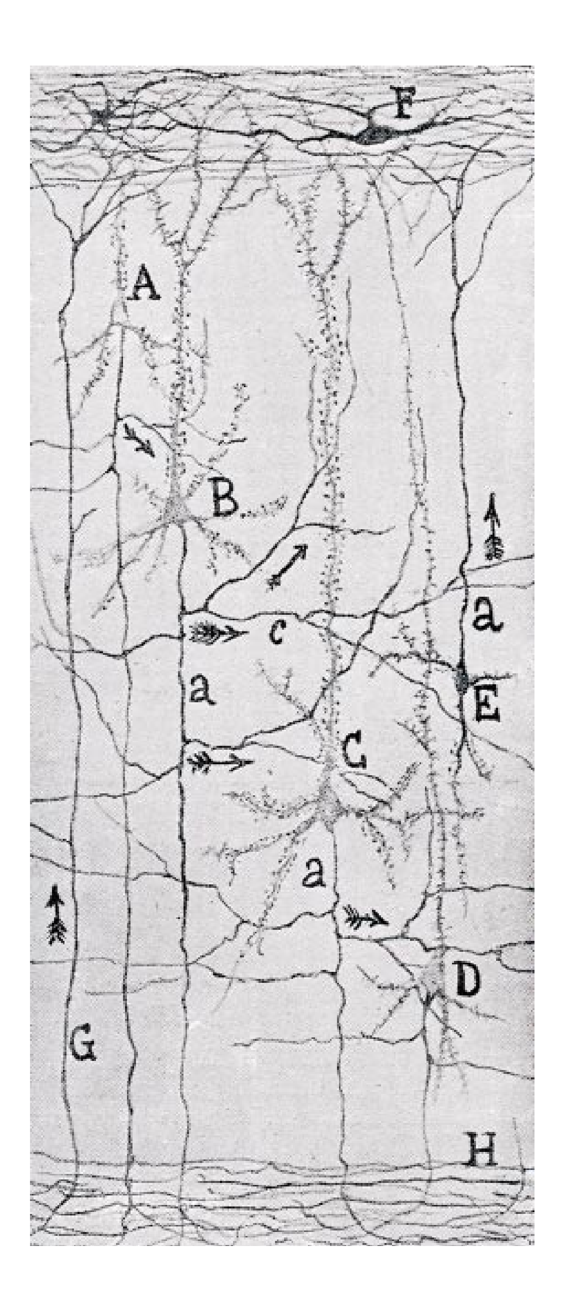




**Figure 5.** Drawing by Cajal of a pyramidal cell in the cerebral cortex of a mouse, stained following Golgi's method. This figure illustrates the typical structure of the pyramidal cell. *a*, basal dendrites; *b* (top of drawing), radial, stem or apical dendrite; *P*, tufted dendritic ending; *c*, axon collaterals; *e*, lower part without collaterals; *b* (lower part of drawing), white matter.
This figure was reproduced in Cajal's book *Textura del sistema nervioso del hombre y de los vertebrados* (Moya, Madrid, 1899, 1904; figures 9 and 668). © Estate of Santiago Ramón y Cajal.

**Figure 6.** Schematic drawing by Cajal to show synaptic connections and the possible flow of information through neural circuits in the cerebral cortex. "… *c*, nerve collaterals that appear to cross and touch the dendrites and stems [apical dendrites] of the pyramids; *H*, white matter; *F*, special cells from first layer of cerebral cortex; *G*, white matter fibre entry. The arrows indicate the presumed direction of nerve current." *A-D*, pyramidal cells; *E*, Martinotti cell with ascending axon. Taken from *¿Neuronismo o reticularismo?* (Cajal, 1933, figure 48). © Estate of Santiago Ramón y Cajal.

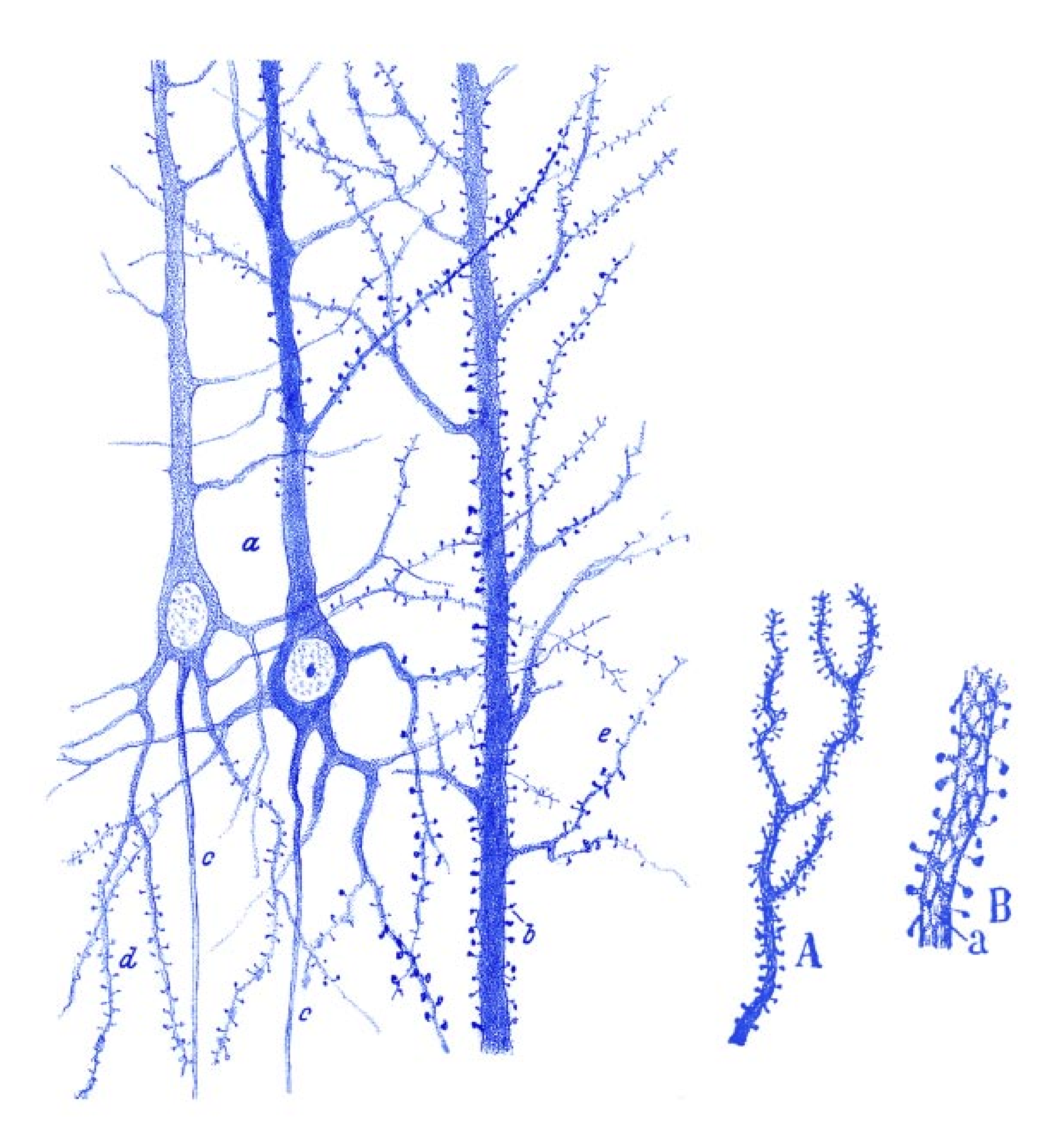



**Figure 7.** Drawings by Cajal to demonstrate the existence of dendritic spines with staining methods different from Golgi's method. Left: dendritic spines on pyramidal cells in the cerebral cortex (methylene blue method). Right (*A*, *B*): dendritic spines of Purkinje cells in the cerebellum (Ehrlich's method).
These figures were reproduced in Cajal's book *Textura del sistema nervioso del hombre y de los vertebrados* (Moya, Madrid, 1899, 1904; figures 13 and 14). © Estate of Santiago Ramón y Cajal.

to the passage of the nerve current between cells. To explain how learning occurs and how motor abilities are acquired with practice, Tanzi theorized that the frequent passage of nerve impulses through a connection produced hyper-nutrition and hypertrophy of that passage and would lead, as in muscles, to an elongation of nerve endings. This elongation would cause the distance between contacts to shorten, increasing the functional capacity of nerve cells in the hypertrophied passage.

In 1894, Cajal continued developing his hypothesis on cerebral gymnastics and presenting his ideas in various publications, especially in an article titled *Consideraciones generales sobre la morfología de la célula nerviosa* (General considerations on the morphology of the nerve cell) (Cajal, 1894). In this article — his first essentially theoretical publication — he clearly stated the possibility that, with plasticity, neural connections might increase in response to a continuous stimulus:

> [...] it can be considered quite likely that in the most heavily used cerebral areas, mental exercise causes greater development of the (dendritic) protoplasmic apparatus and the collateral nervous system. Thus, the existing connections among certain groups of cells would become markedly reinforced through the multiplication of the branches on the ends of the protoplasmic appendices and nerve collaterals; in addition, due to collateral neoformation and protoplasmic expansions, completely new intercellular connections may be established.

He also proposed a hypothesis on the influence of environment on the development, structure and function of the brain. He posited that we inherit a certain number of neurons with a certain tendency to connect, forming synaptic circuits, comprising what he called "the natural personality." The environment (education, family and physical environment, etc.) would affect the neural elongations, increasing or decreasing the connections among those inherited synaptic circuits and even forming new connections with other neurons, creating new circuits. This is how the "adaptive personality" would be created, which could improve the brain's capacity.

Of course, some Cajal's ideas, such as the influence of education on mental processes, had been suggested long before by teachers, philosophers and doctors, but the significance of Cajal's hypotheses was that he tried to explain mental processes from a structural point of view, based on the neuron doctrine. That is, the free arborization of neurons would more easily explain the formation of new connections; otherwise, if the nervous system comprised a continuous network, it would be, to cite Cajal (1894), like a "sort of set of telegraphic wires where no new stations or new lines can be created." To Cajal, it was evident that this rigid, unchanging view of cortical circuits contradicted the general impression that our character and mental capacities can be modified, to an extent.

Most surprising is the clearly modern flavour of his hypotheses, given that, several decades later, experiments with animals exposed to enriched settings (e.g., a larger cage with objects to play with and explore) showed an increase in their cerebral cortex of dendritic branches and spine density (reviewed in Nimchinsky *et al.*, 2002; Segal, 2005). Studies on the cerebral cortex of people with differing educational levels (less than secondary education, secondary education

and university) yield results similar to those found in experiments on animals, showing a correlation between the complexity of dendritic trees and the person's educational level: the higher the educational level, the more complex the dendritic trees (Jacobs *et al*., 1993). In conclusion, it is still surprising that Cajal, using rudimentary microscopes and techniques, was able to formulate hypotheses so close to modern knowledge. In fact, there are numerous examples of highly sophisticated modern techniques that rediscover Cajal: a historical lesson to remember.

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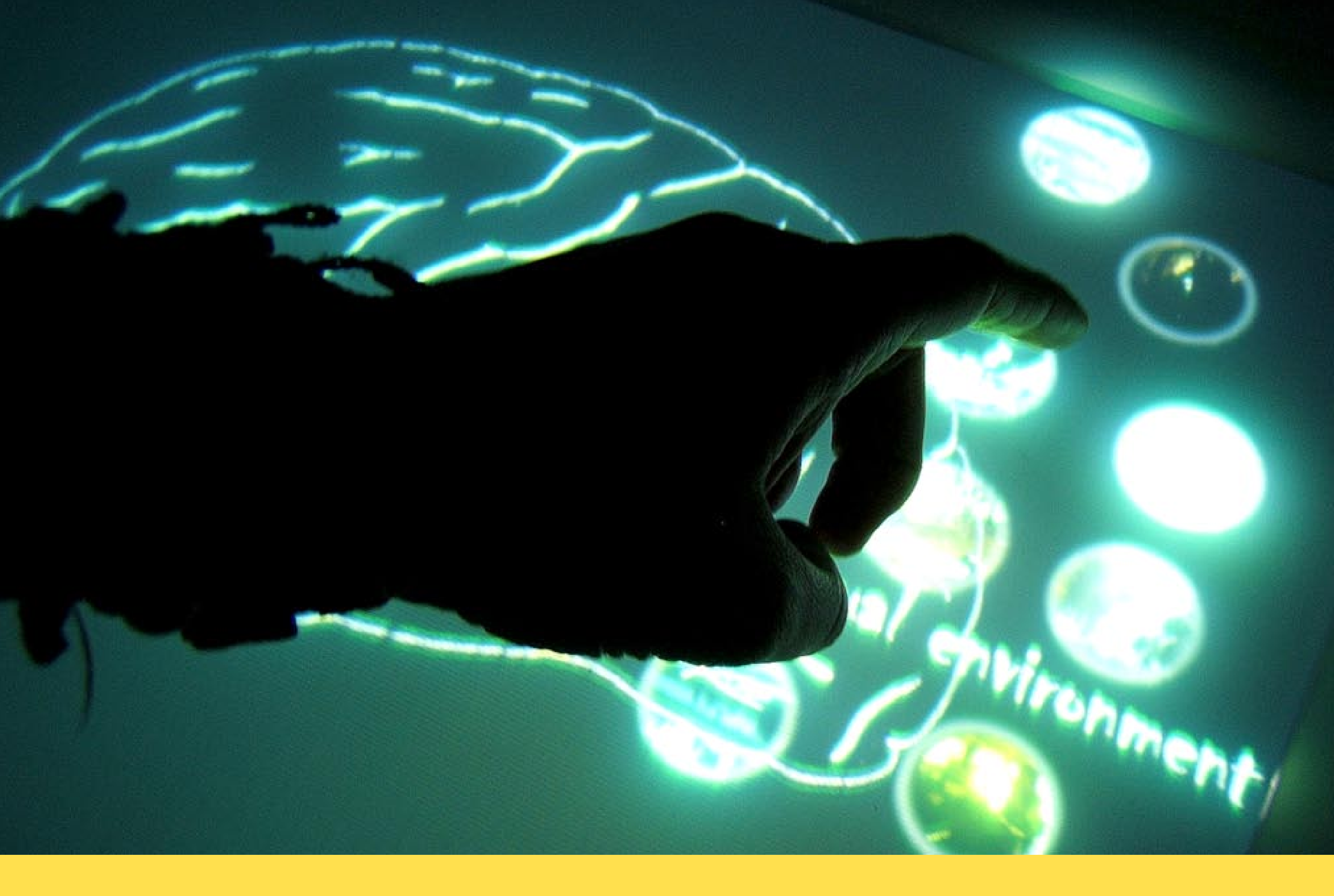






ÁGUEDA SIMÓ
***Reflecting JCC. Brain Research II***, 2007

What is the difference between a normal and an abnormal mind? A balanced mix of rational thought and emotion guides our social behaviour, but what happens when the emotions prevail over good judgement?
Or when reason is devoid of emotional content? The nervous system, neural circuits, specialized areas in the brain and consciousness are all areas for study by humans, who like to dissect themselves to understand their representation of the world and interaction with it: their behaviour. Neurons, synapses, maps of brain function are scientific facts that seem quite familiar to us today but were not discovered until the late 19th and early 20th century. They emerged in part from discussions among reticularists, neuronists, phrenologists and others who studied the brain and human behaviour.
In the 21st century, breakthroughs in research in the neurosciences and psychopharmacology mean that a growing number of people are being treated with antidepressant medication and stimulants after being diagnosed with mental illnesses.
The treatment of serious behavioural illness with a prefrontal leucotomy or lobotomy has been replaced by what is known as a chemical lobotomy, although brain surgery is still performed in extreme cases, such as bilateral cingulotomy for severe bipolar disorder.




This work offers a reflection on the prejudices that colour our view of mental illness and the person who suffers from it, as well as medical-pharmacological interventions to normalize human behaviour and solve social conflicts.
In JCC the user explores the mind of a person whose emotions disturb his reasoning. Provided with a map of JCC's brain, the user establishes connections among his perceptions, thoughts, memories and the external world. The user explores his mind and consciousness, his feelings. At the same time, the user investigates brain function at different levels, some scientific and others more in the realm of the fantastic.
**Á.S.**

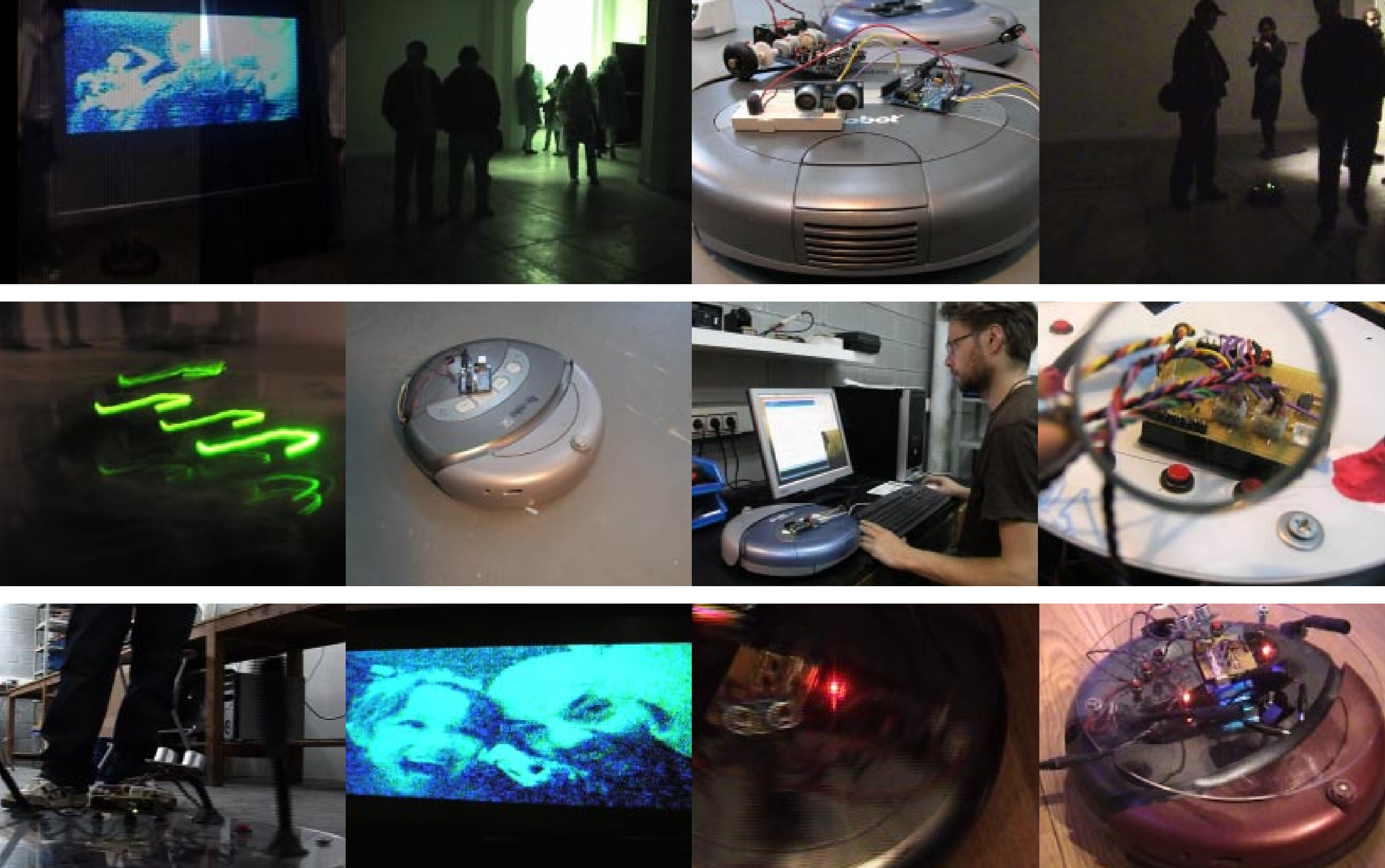


RICARDO IGLESIAS
***José, an Autistic Robot***, 2007

The simple fact that the word “robot” comes from the word for “servant” in Czech demonstrates that the notion that robots were created to serve us is deeply embedded in the popular psyche. They bring to mind Homer’s golden maidens, the mechanical assistants built by Hephaestus, the ancient Greek god of metallurgy, or the first stories of automatons during the Han dynasty of ancient China. Mythical tales, fantasies and true events throughout history show that while the development of robots has pursued the ideal of an automated anthropomorphic servant, there are also deep fears lodged in our imagination that machines might rebel against humans, throwing off the shackles of slavery.

While Cybernetics established the basis for the science of controlling machines, it was gradually transformed into a complex dialogue with those machines due to the need to create structures epistemologically adaptive to the environment to achieve improved functionality. We have gone from control over to dialogue with machines and today we share our everyday lives with all kinds of small robots at our service, which form part of our environment, handling the menial tasks we are unwilling to do ourselves.

But what happens if we can no longer communicate with the robots we live with? What happens when a robot does not respond properly to external stimuli? What ontological status does



that robot acquire, once freed of its functionality and dependence on humans? To explore these matters, Ricardo Iglesias created *José, an Autistic Robot* with social aversion and no communication with the environment. That is why José does not respond normally to external stimuli. Instead, he shows fear when faced with any kind of contact or interaction with humans that upsets his inner world, as occurs in autistic behaviour.

José, equipped with his Arduino microcontroller, his sensors that allow him to perceive his environment, and his activators that allow him to move around, takes on an unusual presence as he behaves absently, avoiding any interaction with his active environment. José moves through solipsistic loops, goes into a panic when he perceives that he is completely surrounded, shows anger if caressed, and displays the range of his adverse reactions to communication, reversing the image of robots as submissive, obedient, controllable machines with no autonomy or independence in relation to human plans. As a result, José acquires a name of his own.

**P.A.**



DANIEL CANOGAR
***Tangle***, 2008

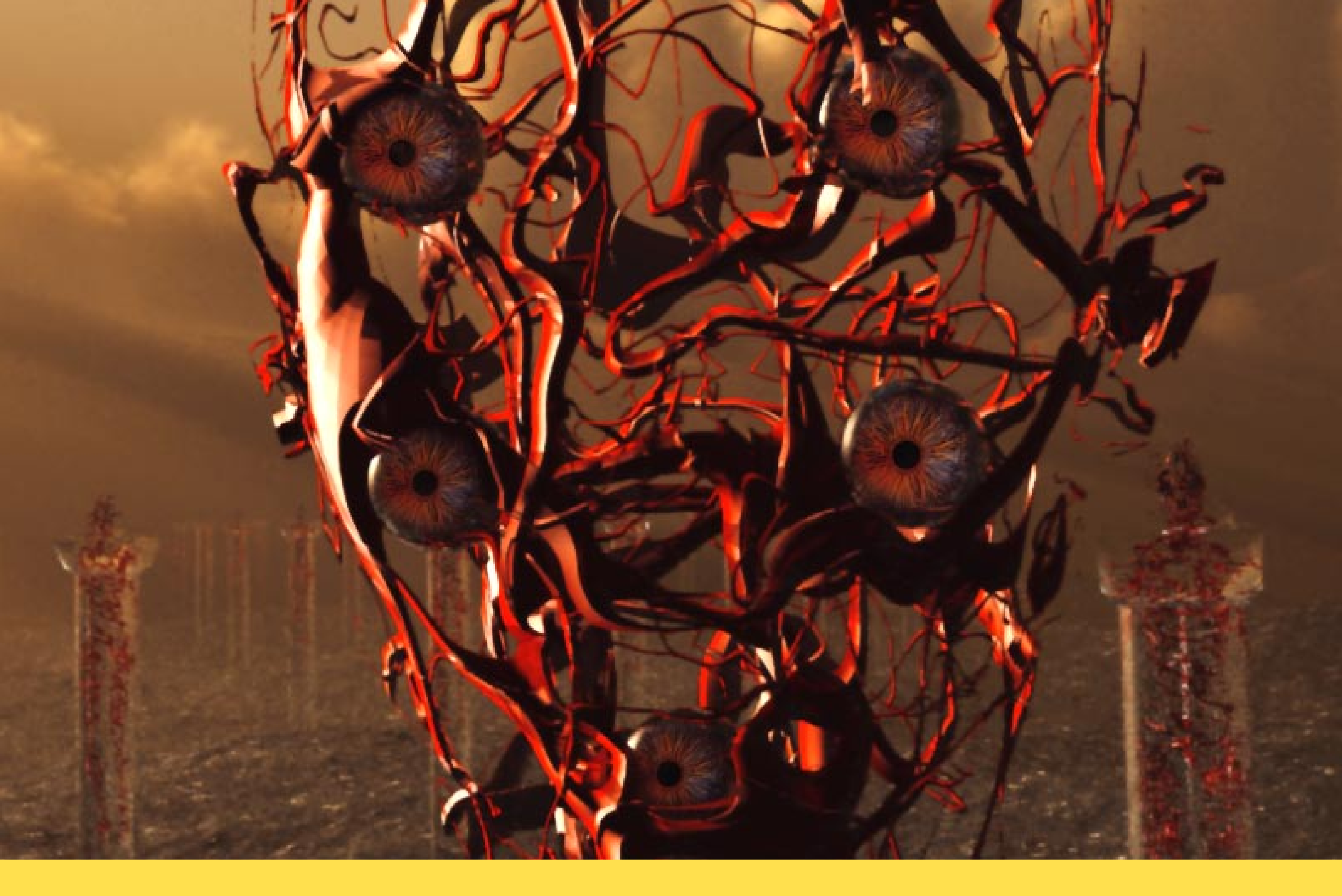
Canogar's *Tangle* is a delicate-looking weft of threadlike cables, small light terminals that look like fireflies and kaleidoscopic projections. Halfway between an enchanted garden and a deep-sea trench, it is an evocative though not necessarily threatening space. And yet, when we walk in it, we can see our shadow trapped in the tangle of projected cables. That is when we understand the work's second dimension. Technology is able to create artificial paradises based on organic forms, emulating biological behavior, and that is precisely the trap — the spiderweb — reflected in Canogar's work.

In the Graeco-Roman myth, Arachne was a virtuoso weaver who challenged the goddess Minerva. She thought herself a better weaver than Minerva and even went so far as to weave tapestries that dishonoured the gods. To punish her, Minerva turned her into a spider. Indeed, no matter how sophisticated their looms, the work of mortals always collides with one furious god or another. Canogar resorts to electronic refuse to denounce a consumerist, technologized society that brings development but also alienation, and *Tangle* has some nuances that reach even further. Art and technology are born of the shared classical concept of *techne*. From a philosophical standpoint, they also share the ontological foundation of verisimilitude,



appearance, the simulacrum of reality, the shadow lying between reality and its projection. When art adopted cinema, and later video, it seemed to have overcome an age-old chimera: the depiction of movement. Movement is the first vital impulse and thus a favorite motif in the quest for technical or artist verisimilitude. Still, the moving image cannot avoid being something that already happened. The image itself is not movement, it merely reproduces movement. Even when that reproduction occurs in real time, the movement is processed and projected on a screen that alters its natural perception. Canogar is interested in the surface on which that image is projected, and inevitably trapped, thus demonstrating that technology and art will always be simulacra — more or less believable, but still simulacra, no matter how sophisticated our looms may be.

**M.Sy.**



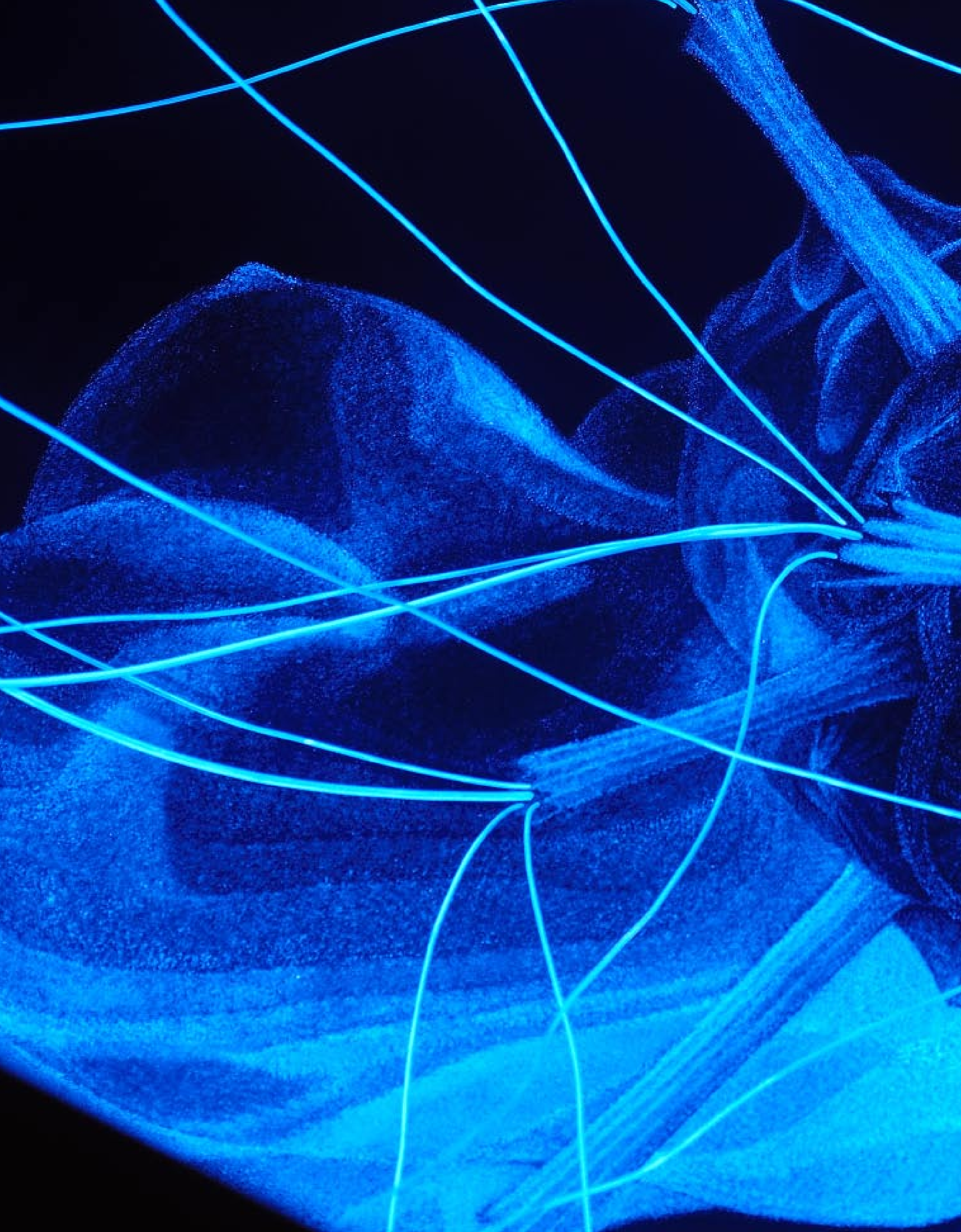
MARINA NÚÑEZ
***Untitled (science fiction)***, 2001

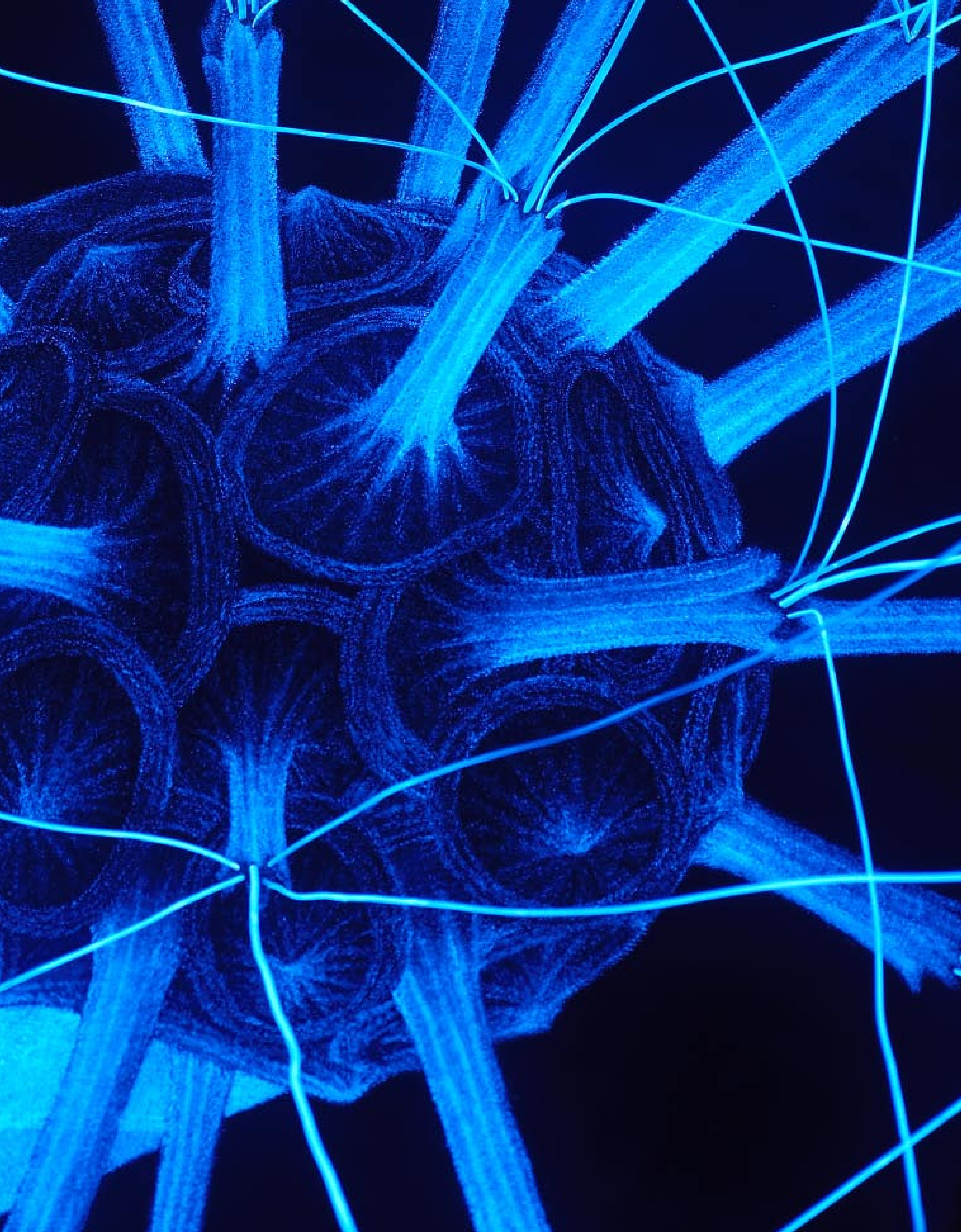
In the same space, we find two installations that deal with the hybrid, connective nature of new bodies. Suspended above visitors, there are five visions of the prosthetic body that techno-science and its unlimited progress offer seductively. Nine Cyborg bodies where flesh and technological artifact are merged in an operative symbiosis flying over the exhibit room. Men and women who have gone beyond the mere expansion of their capacities through the technological to become new beings, half-human, half-machines (satellites, antennae...). Below, at their feet, four black cubes show or point to a detailed look at the symbiosis between artificial network and biology. In each cube, there is a different point of connection between the human body and an indefinite external network (the unknown other). Perhaps only four different biologized IP.
Both visions, although apparently metaphorical like the Cyborg figure was for Donna Haraway at that time, become progressively less poetic and more descriptive as the "network society" advances with its set of connective devices/interfaces. The gradual but exponential unfolding of cybernetic, telematic, and medical technologies on bodies is destroying such deeply rooted concepts in the West as the separation between mind and body or between the inner and the outer, perhaps constituting the final subversion of our Platonic and Cartesian legacy. Undoubtedly, it is through this expansion of capacities offered



by the new technological system that a new and different subjectivity has begun to be built. For the subject cannot exist before historically specific (technical) forces make it possible. That Promethean tradition, which stopped in its eager investigations just before it passed through the threshold of life, can only remind us of the past, before the techno-sciences and their unlimited appropriation of nature started to work on the final merger between the biological and the non-biological, between *techné* and *physis*, between I and the Other. *Untitled (science fiction)* shows the evidence of our Faustian tradition. The one that has no limits in the investigation and wants to reconfigure relations between what is natural and artificial, between what is inside and outside, between humans and their connections. For if something is definitely emerging from this profound change, it is the generation of a new pattern of networks where there is no separation possible between any sphere, no matter which. Connectivity is already outlining a new landscape without borders, a state of total flux, hybrid and omni-comprehensive: the network of techno-life.

**A.S.P.**

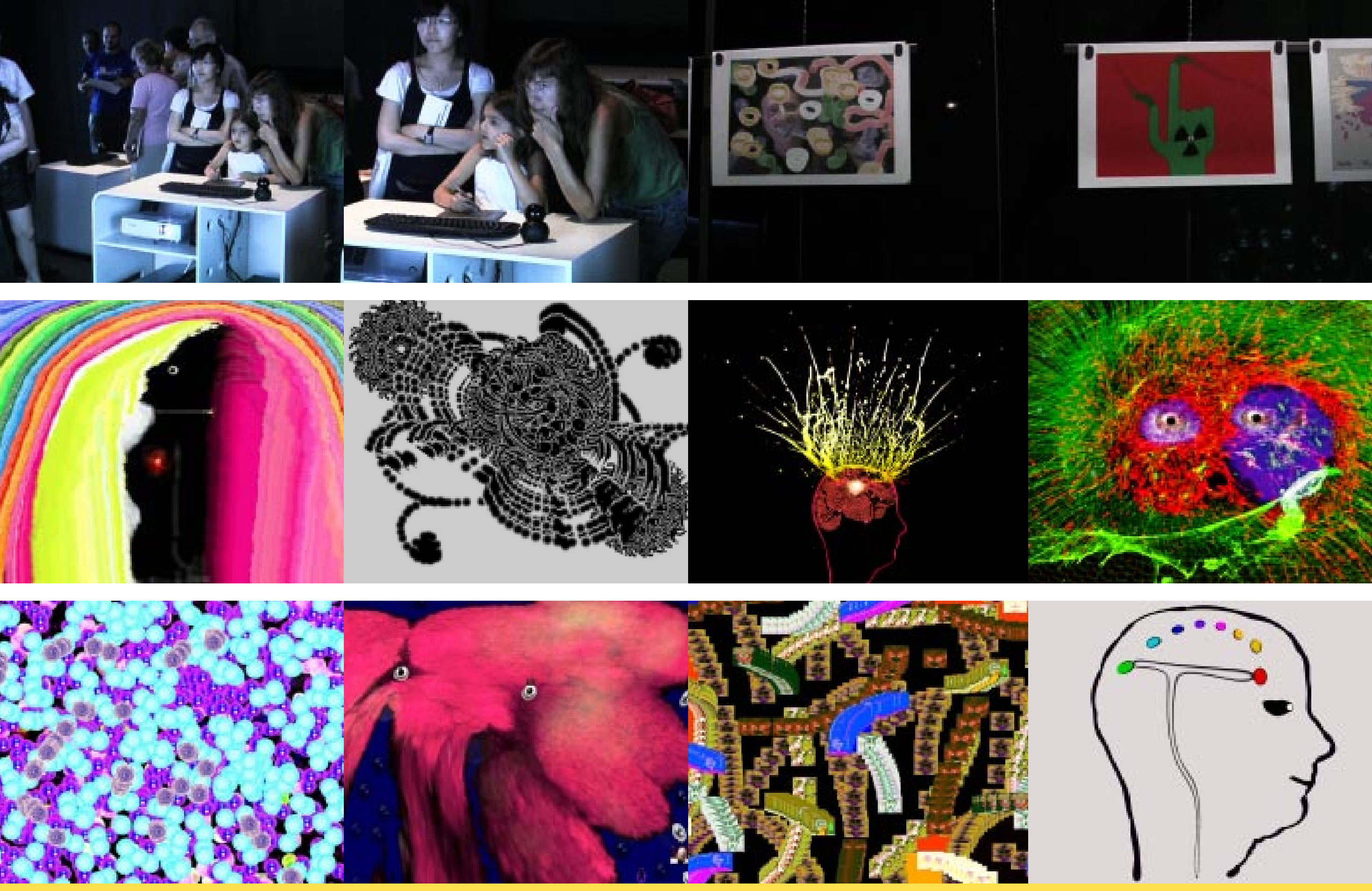






EVRU
***Tecura 4.0***, 2005-2009

Development today in the neurosciences gives special importance to the role of the organic, to its materiality, as the basis of all knowledge. The Cartesian dualism that formerly classified reality according to the separation between body and mind, and which, by de-materializing the mind, promoted the equivalence between mind and calculation machine, seems to be falling into disuse although it still has a place in the popular collective imagination.
The role of the body, the organic, materiality, and the biological processes that structure the networks we move in today are increasingly significant. Their models of functioning are being exported to promote types of fields in the search for solutions to situations where self-organization is needed to solve problems of over-saturation or great complexity.
In this context, Evru has developed its own method of "Arsciemistism" (a combination of art, science and mysticism), granting preferential status to the organic, with its icons, the eye and the brain, as the focus of its concerns. The corporeal organism receives feedback inserted in networks interconnecting everything with everything else, and the body becomes the direct translator of the mind. In this interconnection of icons of all types, Evru incorporates digital technologies to explore the potential structuring and expansion of these networks and the attributes related to computational sciences.

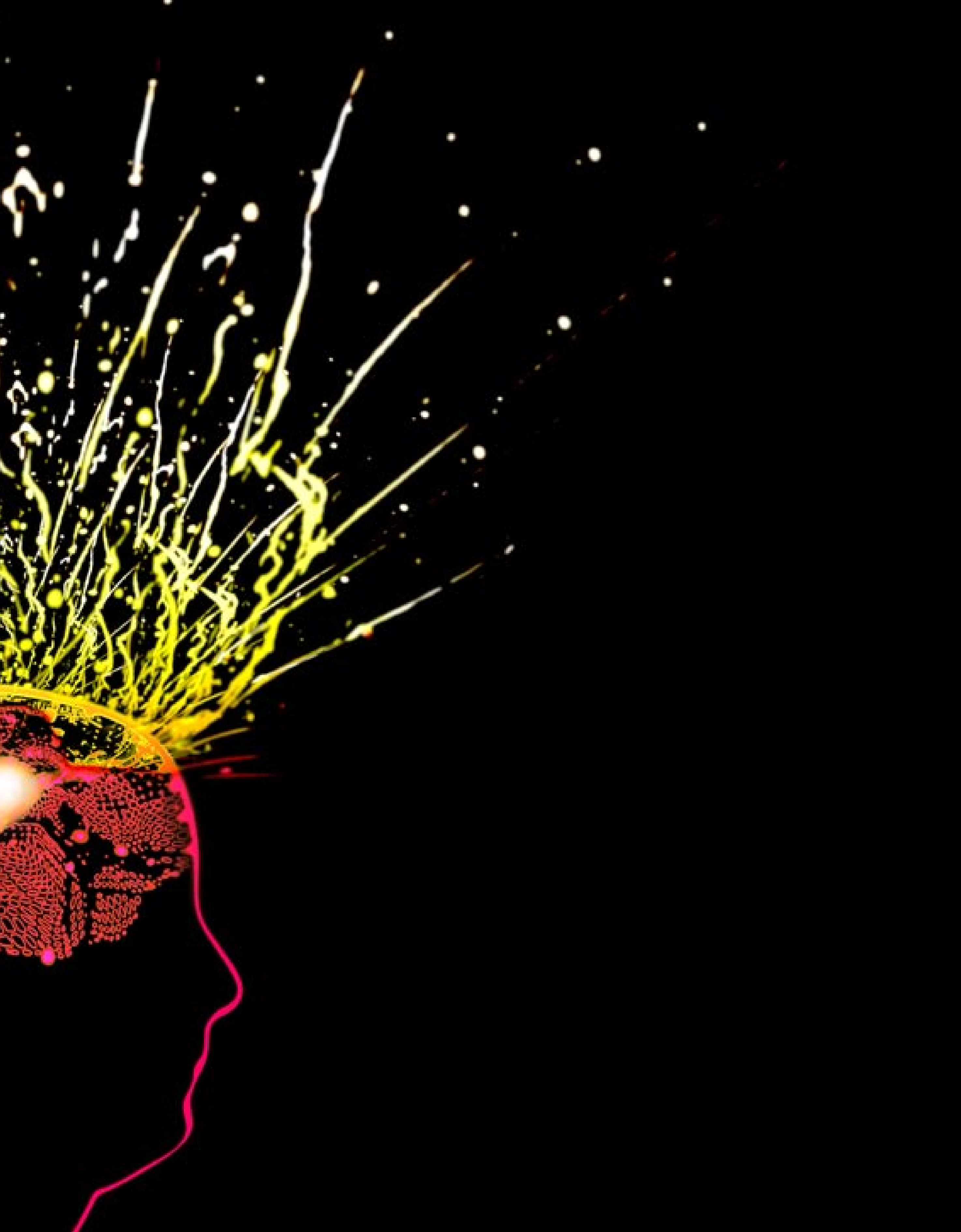


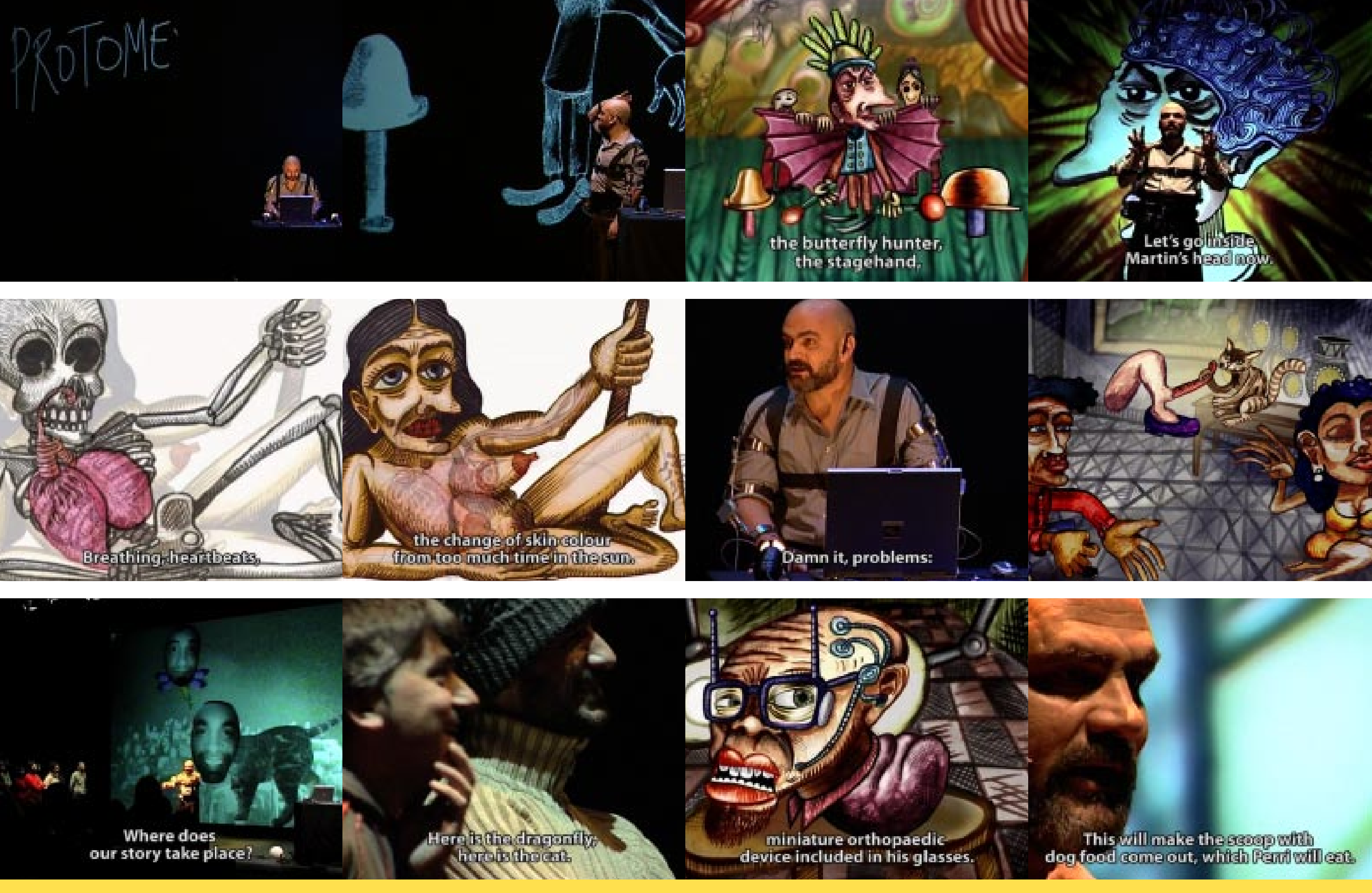
# TECURA

In *Tecura 4.0*, Evru extends itself, becoming a meta-artist, symbiotically connected to the user, who can alter, modify or expand the elements previously made available by the artist. It offers an interactive application for network visual and sound creation, generated based on the artist's own language, providing users with a supply of images and sounds they can use to make their own creations. This way, the author is not placed at the centre and fosters art for everyone, not only for artists, enhancing work by network. *Tecura 4.0* is also a curative programme that heals through an artistic praxis not based on the rational structure of languages but instead on playing with the sum of madness and hallucinations emerging from reality itself.

**P.A.**

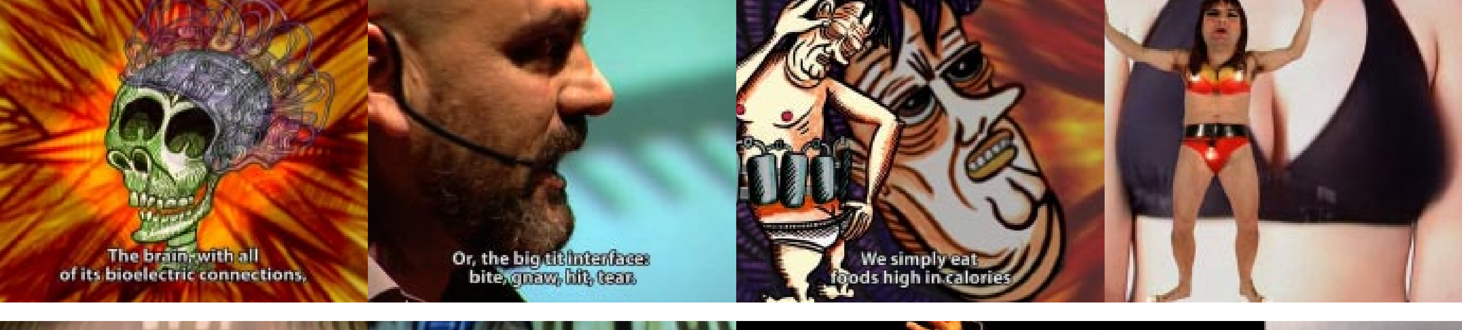






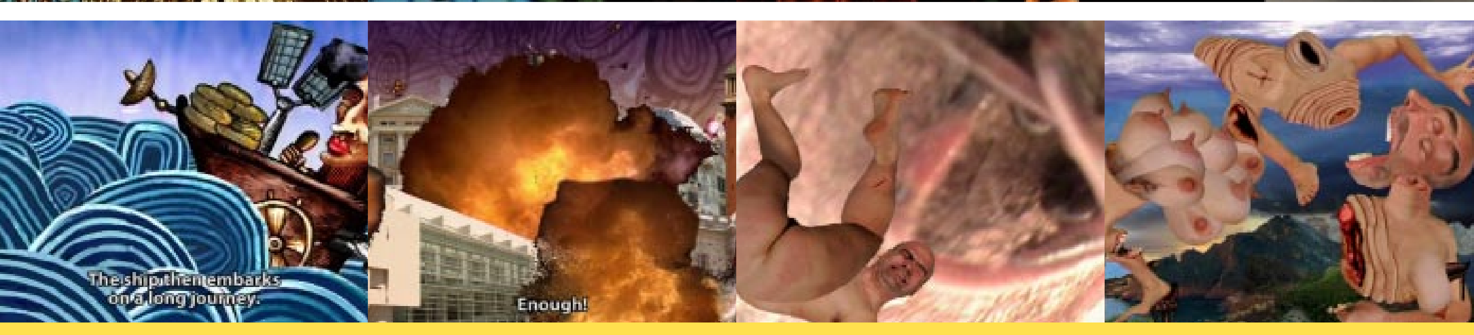

MARCEL·LÍ ANTÚNEZ
***Protomembrane***, 2006

*Protomembrane* is presented as a theoretical and practical lesson on systemwriting; that is, on "playwriting" for computer systems. Using words, music, and graphic animation as a multimedia whole controlled via interfaces, Marcel·lí Antúnez has structured this action as a performance and an interactive lecture. Along with the artist's verbal narration, computers, projections and images of the audience taken by a pistol camera combine to weave a narration that is continuously being created. More than a metaphor, the complex nature of *Protomembrane* is best understood as an epitome, as a direct, effective demonstration of the emerging horizontal narrations made possible by new forms of digital communication.
A rational basis for understanding the world was methodical, linear, progressive and geometrical, its literacy comprising of coordinates, the abscissa and the ordinate, and rigorous order. That cognitive foundation has been substantially modified, first by visual culture and then by digital culture. The technologies of language, with their temporalization and sequencing, were shaken up some time ago by the audiovisual culture emerging at that time with its dynamic, synthetic form of cognition. However, the digitalization and interactivity of the new participatory on-line media have reinforced this linguistic transformation dynamic by contributing collaboration, interactivity, decontextualization and recombination,










all present in the ongoing conversation taking place on the World Wide Web. *Protomembrane*, as a collaborative, multimedia narration, presents and exemplifies a new form of generating and processing narrative. This is narrative 2.0 or higher. A paradigm shift like the one that took place in science in the shift from linear to non-linear systems.

With a view to cybernetics and the problem of communication between machines and bodies, as well as connective thought, *Protomembrane* influences the plots of narratives in the "network society". They are a web of non-linear linguistic structures with feedback loops able to self-organize their own communication flow based on audiovisual media. A textuality that has gone beyond the digital to become autopoietic.

A new way of narrating, knowing, and therefore, of thinking. That's what is actually at stake in the transition to the psychodynamics of today's digital culture.

**A.S.P.**





*It is in the phenomenon of digital noomorphosis (from the Greek* **noos**, *meaning intelligence, and morphosis, meaning formation) that the greatest and deepest digital gap — dividing the digitally native, the digitally immigrant and the digitally illiterate — may be arising, if we evaluate that gap as we should, that is, in terms of a new social, mental and ethical ecology.*

**Fernando Sáez Vacas**

# Networks and owners of knowledge

Ernesto García Camarero

When speaking of technological convergence, there is too much emphasis on technology. It seems as though this is meant to mask the real essence of the new situation. Certainly technology plays an important role in training our society. However, this has always been true. We believe that overvaluing the role of tools distracts us from their aim, which must always be beyond the tools themselves. It is not the tool that is of true significance; what matters is its purpose and how it is used. Today, it is in fashion to speak of new technologies as if the current ones were to be the last. Science and the scientific method are mentioned less. Technology is presented as if it were magic. Numerous unnecessary neologisms and incomprehensible abbreviations make up a lexicon, for experts only, which makes it more difficult for most people to approach the nucleus of scientific and technological knowledge and hinders their participation in its orientation and development. They know only that behind the technique — controlled by those in power — are the scientists, who possess the unquestionable truth, like priests and

vestals that create and watch over an inaccessible knowledge.

Therefore we find the concept of society espoused by this publication excellent, where it is considered, not as a tree, but as a network that connects all individuals, with their social dynamics and art, science, and philosophy (natural and moral), for their personal emancipation, thus offering a new way of understanding reality and constructing society. Technology, considered as the evolutionary result of applying science created throughout history, is only an instrument. It belongs to all of society, which must not lose control of it or delegate its ownership.

*

Human beings exist within nature, are part of nature, and have evolved with nature. In order to live, develop, and evolve, they need nature, in a permanent exchange of matter, energy and information. Through natural evolution, this exchange has produced the genetic code: a biological language that is manifested internally in the metabolism, and also through instincts, which guide immediate and elementary decision-making. Moreover, the information supplied by nature, perceived through the senses and elaborated collectively by the human brain, has produced culture (social knowledge), expressed and accumulated through articulate language (science and technology, first orally, then through writing and other means), which is the base of social evolution. Science and technology are cultural realities.

Writing, a technical invention, enabled greater accumulation of knowledge and the sending of messages at a distance. To be in possession of writing was to be the owner of accumulated knowledge. Producing knowledge depended only on the experience, ability, and freedom of the individuals grouped together. This dichotomy of producing and possessing, which has been present since Neolithic times and is still valid, poses a number of questions. How and where is knowledge created? Who is its owner and what is its use? These are complex questions with difficult answers, to which several philosophers and historians have dedicated their efforts.

*

I believe that in broad terms, knowledge has two origins. In some cases, ideas as to what things are like come from theological considerations, supposedly obtained through divine revelation, or from superstitions or esoteric beliefs received by wizards or visionaries endowed with special powers and who can get results that no others can. This is how theologies and myths are made. In this case, ownership of wisdom belongs to the sect that keeps watch over it and ensures its orthodoxy.

In other cases, ideas are made by directly consulting nature through action and observation, aided by tools and instruments; theories are constructed through the ordering and synthesis of accumulated data, verified through experiments and experience. These tasks are not performed by wizards or visionaries, but rather by people with training that anyone can access who uses their own intelligence. In this case, practical, theoretical and applied knowledge belongs to each individual who uses it in his everyday work or for his own pleasure, and shares in tasks that require teamwork.

This primitive and schematic set up has evolved throughout history and taken different forms in its relationship with the establishment of

human societies. In 300 B.C., in Classical Greece, the kind of knowledge we call scientific today began and since then a path has been cleared (between freedom and subjection) keeping antagonistic company with dogmas and myths that are ancient, modern and of recent construction.

The libraries of antiquity (Pergamum and Alexandria, among others) were the first repositories of accumulated knowledge in manifold documents, and replaced the knowledge enclosed in singular sacred books. With great effort and difficulty classical knowledge was preserved along with theology in the libraries of medieval monasteries, where there were also workshops of scribes. Thus they maintained control over and ownership of ideas by impeding the making of copies or modifications not authorized by the hierarchy, with the excuse of protecting its orthodoxy and making access to the libraries difficult. In this way, so-called "refined knowledge" was deposited in a network of medieval monasteries and universities. They belonged to and were administered by the Church.

In addition to this refined knowledge, in the Middle Ages, many other kinds of popular wisdom of a practical nature arose that helped farmers and craftsmen in their everyday tasks and were passed from masters to apprentices. Although there are many examples of this kind of wisdom, we are going to focus on one — cartography — that illustrates the two aforementioned antagonistic forms of knowledge: atlases made in monasteries compared to maps made in ports.

Monastic cartography originated with the two-hemisphere maps made by Isidoran monks. They represented the world as a circle divided into three parts that indicated the territories occupied by the sons of Noah: Ham, Shem, and Japheth. According to primitive Biblical references, they

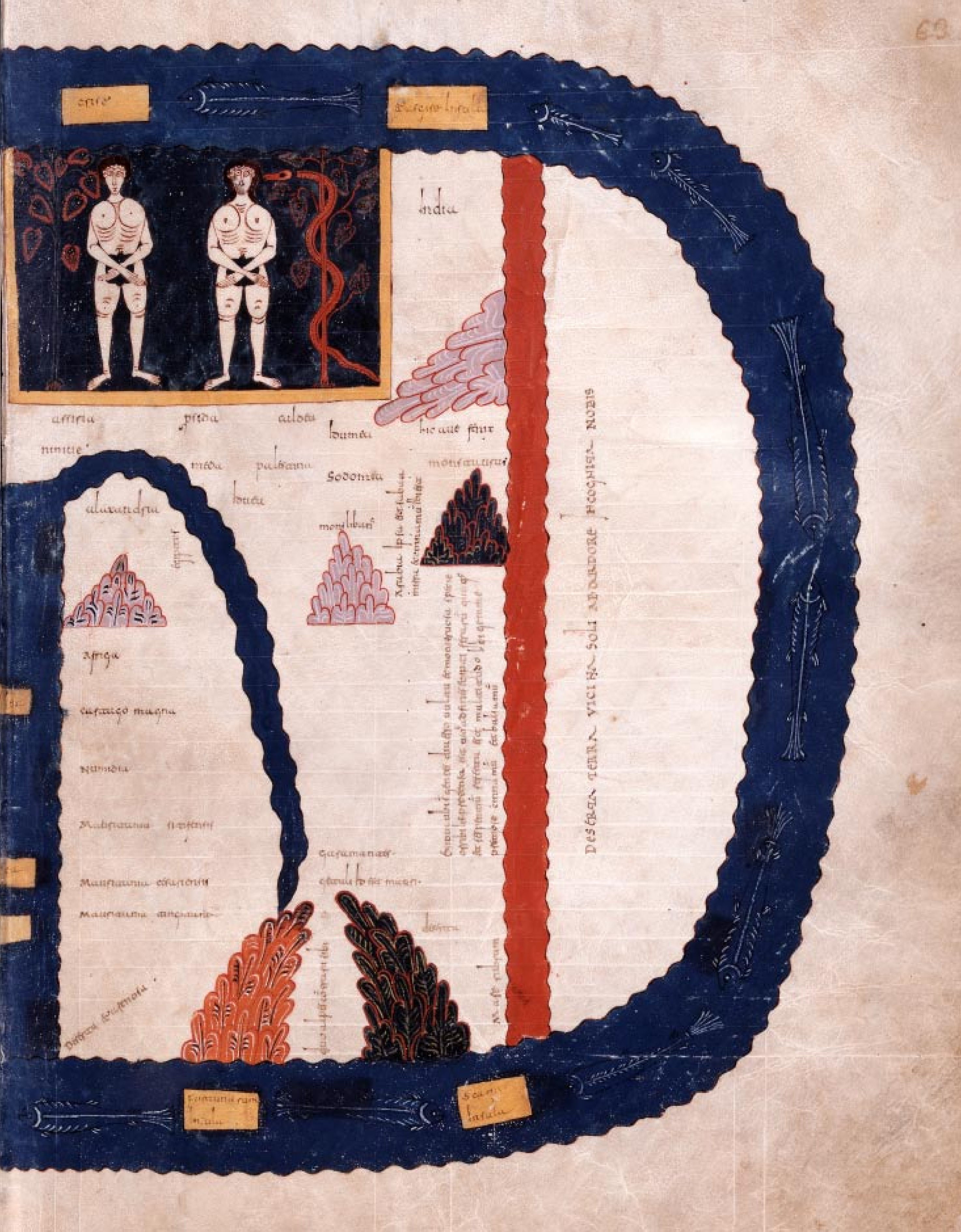



*Etimologias de San Isidoro de Sevilla* (Biblioteca Nacional, Madrid).

allegorically correspond to the three continents: Africa, Asia and Europe. This schematic representation was subsequently expanded with new Biblical information (an earthly paradise in the Orient, Adam and Eve with the Tree of Knowledge, the serpent, etc.), as can be seen in the monumental manuscript with the Commentaries of the Apocalypse done by the Lay Brother of Liébana (Santander) before the beginning of the second millennium, and in other much later maps. In its evolution, however, its purpose did not change: to represent ideas held about the world rather than the world itself.

As opposed to monastic cartography, a new kind of map appeared: port atlases, which did not reflect geographic ideas, but actual data taken from the real world. How did this happen? The real world itself provided the method: using the compass, which always points north. That is a fantastic property that has nothing to do with magic, but with the earth's magnetic field, and it allows us to set a sure course to sail from one port to another. These maps, in contrast to the earlier ones, were not made in monasteries or universities, they were made in the ports (Palma de Majorca, Genoa, Venice, etc.) with information obtained by sailors


caucasus mons
albania
terra babilonia
constantinopoli
pannonia
gallias
germania
narbona
roma
tarracona
spania
olisbona
Britania insula



India
Sodoma
Africa
Numidia
DESERTA TERRA VICINA SOLI ARDORE INCOGNITA NOBIS





and organized in artisans' workshops by master cartographers and their apprentices, to make that information available to others.

These two approaches to cartography provide us with an example of theological, dogmatic and scholastic thought versus scientific thought constructed with information obtained from nature and subjected to the verification of its use. Moreover, the example of the atlases helps us to see that scientific truth is always relative, fragmented and conditional, in permanent change. It is a wonder to see that the representation of the Mediterranean in the first atlases practically coincides with a current map of the same area (both using the same scale). It is also surprising that it is not possible to get a "completely true" representation of any part of our world from a map (for the simple reason that it cannot be made from a sphere), although we can affirm with certainty that the courses in the atlases coincide with those the helmsmen must take.

*

The printing press was a tool that broke down the walls of the libraries of monasteries and universities, in which refined knowledge was hermetically kept, and for the first time, different kinds of knowledge were mixed and knowledge had a potential medium of universal dissemination.

The development of navigation and the printing press opened two overlapping worlds to discovery, the first geographic and the second philosophical and scientific, which brought the Renaissance and the Modern Era. Soon the superiority of scientific knowledge was valued over scholastic knowledge for obtaining practical results, although dogmatic knowledge was maintained to preserve power.

Given the practical superiority of scientific knowledge, in the 16th century a new kind of institution appeared. Examples include the Casa de Contratación de Sevilla (created by the Catholic Monarchs in 1503) and the Royal Academy of Mathematics of Madrid (created by Philip II in 1584), the former for the systematization of navigational, geographic and cosmographic knowledge of the new continent to regulate and secure the commercial exploitation of the Americas from Castile, and the latter with the intention of developing the science and technology necessary to manage the double empires of East and West from El Escorial.

But beyond state institutions of this kind, in the 17th century, Galileo, Descartes, Fermat, Pascal, Newton, Leibniz and other "free-thinking philosophers" began a scientific revolution that spurred the growth of theoretical knowledge of society and nature, surpassing that of classical authorities. Although this activity began in salons, it slowly became part of scientific academies, institutions that were separate from universities and monasteries, placed under the protection of monarchs for the benefit and prosperity of their crowns. Thus appeared the Accademia del Cimento in Italy (1657), the Royal Society in England (1662), the Académie des Sciences in France (1666), the Academy of Berlin in Germany (1700), and the Academy of Science and Art in Saint Petersburg in Russia (1724), among others, making up a network of centres throughout Europe engaged in scientific discovery, connected by means of their books of proceedings and other publications.

However, academies were not the sole or even the main producers of scientific or technological knowledge as guilds and craftsmen also did so in workshops and factories. Numerous machines of various kinds were invented and

constructed, in particular Watt's steam engine, symbol of the Industrial Revolution. This machine (patented in 1769) was manufactured in the Boulton-Watt factory (with its own laboratories for the development of new inventions) and represents an early example of how to produce knowledge outside of the old institutions, not just the medieval monasteries and universities, but also the more recent academies. These technological and craftsmen's activities comprised ever more complex networks, grouped together in associations, societies, and other kinds of institutions to encourage the growth of knowledge applied to agriculture, industry and commerce.

The first steam engine dates from 1776, the same year as the Declaration of Independence of the United States and the appearance of *The Wealth of Nations* by Adam Smith, and is therefore the symbolic year of the beginning of the Industrial Revolution and economic liberalism (for which land, labour and capital are the absolute axes of the production of wealth).

Although knowledge began to be considered a new kind of wealth, it still lacked a legal frame that allowed it to be appropriated. The philosophers of the Enlightenment thought reason and science should be freely accessible and at the service of man and his rights. The methodical *Encyclopaedia* of Diderot and D'Alembert was written with the express aim of setting all knowledge within reach of anyone.

*

Industrialization and the need for new markets, ever farther away, increased the international scope of industrialists and merchants, who needed to free themselves from absolute monarchies. England had gained new freedoms with the Puritan Great Rebellion, which took Charles I to the scaffold. In France, a century later an absolute monarchy continued in power. The new moral and natural philosophy led to the French Revolution, and as the monarchy refused to listen to the voice of reason, violence was used, which cost Louis XVI his life (1792).

In revolutionary France, neither traditional universities nor academies were enough to create the knowledge necessary to construct a new society. To this end the prestigious L'École Polytecnique and École Normale Superieure were created, as well as other minor schools, from which sprang the forces dedicated to constructing the social and economic infrastructures of the Republic. And although Napoleon abolished the Republic soon thereafter, he did appropriate its scientific and technological advances to reinforce his power, subjecting the university to the State and militarizing the Polytechnic School, to create the civil service corps that managed the Absolutist State of the Empire. Many European countries adopted Napoleonic reforms. There was also a proliferation of scientific societies, museums and other institutions promoted by nascent industries. There were national and international scientific congresses, world's fairs and scientific journals and other publications began to be published. Thus, widespread networks for the production, dissemination and appropriation of knowledge were created.

*

The disperse initiatives of the $19^{th}$ century were concentrated at the beginning of the $20^{th}$ century in national scientific research institutions. Thus, the following entities were created or consolidated: MIT in the United States (1904),

the Imperial College of Sciences and Technology in the United Kingdom (1907), the Kaiser Wilhelm Gesellschaft in the German Empire (1911), the Junta para Ampliación de Estudios in Spain (1907), the Consiglio Nazionale delle Ricerche in Italy (1922) and the Centre Nationale pour la Recherche Scientifique (1939) in France.

Note that all of these institutions appeared during a time of strong nationalism, which led to dictatorial states and war.

Scientific activity had given rise in the 19th century to the idea or myth of "progress", but the two wars of 1914 (the first technological war: aviation, armour, chemical weapons, etc.) and 1939 (a test of what science and technology could do as instruments of mass destruction) meant that hopes of "progress" plummeted. With the pretext of national defence, the states put all of their scientific and technological potential at the service of war efforts. Their maximum achievement was the construction of the atomic bomb (1945) in the United States with the collaboration of European scientists. The knowledge used came not from initiates, nor from seers invoking magic words, but from the kind of knowledge that can be accessed through study, as a number of other countries demonstrated as soon as they set their minds to it. USSR (1949), the United Kingdom (1952), France (1960), China (1974), India (1974), Israel, (1979), Pakistan (1998), North Korea (2006), and so forth.

After World War II, all of the belligerent nations put scientific and technological research directly under the protection of the State, with numerous policies that only varied from one country to another in minor details. In the Soviet Union, the importance of the state and centralization were a fact from the very beginning. In England, France and Germany several ministries were assigned the control of scientific research. In the United States, state control, begun during the Great Depression (1929), continued during World War II (1939-1945). In the post-war period, the presence of the Federal government increased in universities, foundations and industry, and created several state institutions engaged in scientific research and its application to military affairs, above all during the long Cold War, and the "hot" wars in Korea and Vietnam.

A highly significant American scientific institution was the RAND Corporation (1948, Santa Monica, California), engaged in the invention of devices (supersonic airplanes, intercontinental missiles) and to the study of decision-making (operative research, strategy, international politics, communication) in world scenarios of thermonuclear war. The development of the Internet also began, later a basic tool for the appearance of a new emerging world, but which arose in response to the question: how could the authorities of the United States communicate with one another, and what type of command and control could survive a nuclear attack?

*

The scene, since World War II, was that of scientific research rigidly controlled by the states and oriented toward unbridled economic growth defended by military force, a situation which gave many scientists cause for reflexion as to the poor use of their research, and made them wonder about their own responsibility in its being that way.

Nobel, Linus Pauling, Bertrand Russell and many others had already denounced "death-dealing" scientific activities such as nuclear testing that were not beneficial or life-giving, and they

proposed trials be held for war crimes. Not only respected veteran scientists but also many young people joined a protest that was not limited to the perverse applications of science, but also to the ideological bias that science itself was taking. The old gods were in decline. Therefore, a new set of undisputable ideas was needed to substitute them. "Science" would occupy this place and its doctrine would be scientism. Thus, one of the greatest transgressions of thought was perpetrated: science, which had arisen as an expression of the free discernment of every individual to read the messages of nature and make dogmatisms disappear, wanted to be seen as a set of indisputable ideas to re-establish a new dogmatism that people would revere. This new religion needed its priests and temples organized hierarchically to direct its development, and assure its ownership by the high priests and those who served them. In this scenario, an antiscientific movement appeared in favour of maintaining the free way of doing research that must never be lost. Numerous groups in Europe and America and brilliant scientists joined in. However, the antiscientific movement gradually lost visibility, its supporters ended up abandoning the temples in which they practised and their publications no longer had a place in an academic world that was increasingly fundamentalist.

What happened meanwhile to official science? It continued the path that made the thinkers of the 17$^{th}$ century go from free science to a science controlled by monarchs to ensure the "progress of their nations" and later, by the states of the 20$^{th}$ century, to reach supremacy in war and economics, finally reaching in our day science controlled by big business with the aim of increasing profits, in the "belief" that, this way, the birth of a Globalized Brave New World will be achieved.

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When the Cold War became less significant in the 1970s, the United Sates modified its scientific policy, increasing the dedication of the NSF to research applied to development, and in the 1980s Reagan decided that applied research should be financed by the private sector. This orientation facilitated the appropriation by corporations of knowledge in the narrowest sense.

For these corporations, dedicated to pharmacology, agribusiness, bioscience, computer science, big projects, etc., knowledge is a fundamental factor of production, making them buyers of knowledge who need to ensure their ownership, and to this end they lobby to create and broaden copyright laws that benefit them, thereby placing a high concentration of knowledge in the hands of a small number of corporations and firms, around which the academies, universities and national research centres revolve. This monopolistic and closed manner of producing knowledge, which is considered merchandise, is far removed from the benefits imagined by the Greeks, or the thinkers of the Renaissance or the Enlightenment.

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In addition to this closed way of producing knowledge, a new way of approaching the problems of production, dissemination, storage and ownership of knowledge is slowly appearing. It began in the world of computer science to fight against the legal restrictions on the use of the programmes imposed by the software "owner" and the Internet universe to achieve the free use of information accessible through this means.

For to whom does the network belong? Who are the owners of the knowledge thereby generated?

The lawmakers who defended big corporations toughened intellectual copyright laws to increase profits and to this end they used the weak argument of needing to protect the authors. In general, copyright is used to restrict the dissemination of information, but this right can be used by authors for the opposite purpose. To that end, the legal formula *GPL (general public license*, colloquially *copyleft*) (Stallman, 1983, MIT) appeared, through which the user is "allowed" to use, copy, improve and distribute software without restriction, but "mandates" that the new copies, whether or not they are modified, are also protected by *GPL*. The Free Software Foundation was created in 1985 to disseminate free software. Free software was developed thanks to the GNU project and it is distributed mainly by Debian, through interconnected networks in which numerous programmers work together. For some time the GNU/Linux operating system has been used not only by fringe users but also by corporations such as Dell, Hewlett-Packard, IBM, Novell, Oracle, Red Hat and Sun, among many others.

The apparently novel idea of *copyleft* does nothing more than legally restore and protect the usual exchange of programs in the early days of computer science, and it restores the idea of freedom that should characterize the creation of knowledge, and its the exchange and dissemination. This accounts for the appearance of numerous networks with new ideas to produce free knowledge (scientific and artistic), and disseminate it without the hindrance of private ownership.

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If indeed the Industrial Revolution and economic liberalism marked the beginning of a form of production in which material goods were the essential part, at its very core was the seed that would signify the end of this notion. Indeed, upon separating energy contribution from human effort and transferring it to the machines that generated it (motors), which gave rise to industrialization, it became apparent that the axes of the production of wealth were not land, labour, and capital, but rather matter, energy and information. Information had to be temporarily interpreted by humans to be changed into action, until the appearance of machines with this capacity (computers), which produced automation, the automatic way of producing material goods. It is humans, therefore, who can create knowledge that becomes information, but how is knowledge created? To what end must this creation be directed and to whom does it belong? Centralized planning or homoeostatic social networks?

In this text we have provided an overview of the confrontation between the two trends throughout history. At the present time, the great Neoliberal tree faces the gossamer cooperative web that is being spun across the planet. To reach a solution, new technologies may help us, but only human activity will overcome this antagonism.

**Images**

Pp. 122-123. *Beato de Liébana de Fernando y Sancha,* s. VII (Biblioteca Nacional, Madrid).

Pp. 124-125. *Portulano Angelino Dulcert,* 1339 (Bibliothèque National de France).

# A walk through the realm of art and science today

Capi Corrales Rodrigáñez

> Where the world ceases to be the stage for personal hopes and desires, where we, as free beings, behold it in wonder, to question and to contemplate, there we enter the realm of art and science. **Albert Einstein**

Science and visual art work with ideas. The word *idea* comes from the Greek , which means 'to see', 'to look at' or 'to observe', and from *eidoz*, which means 'figure', 'form', 'aspect' or 'vision'. Behind a specific mountain is the idea of a "mountain", an abstract drawing, lines that indicate the mountain behind the rocks, the pine trees or the snow. The difference between this tree and "tree", between a circle we draw on the board and "circle:" the difference between the thing and the idea of the thing. In art and science the ideas of things are sought. In this article we will reflect on some of the ideas apprehended and placed in the spaces of networks woven by contemporary scientists and artists. Let's begin by looking up the words "space" and "network" in the dictionary.

> *Space* and *time*. Terms used in philosophy to describe the structure of nature. At times they are described as containers in which all events and natural processes occur, and at times as relations connecting such events [*Collier's Encyclopedia*].

> *Network*. Organization of services or things linked or related to each other [*Diccionario de María Moliner*].

The two words, *container* and *relations*, describe respectively the idea of "space" that we find in the 17th century, the first explicit mention of the concept of "space" in mathematics, and the idea of "space" in contemporary mathematics. In the 18th century, Newton defined "space" as an absolute, infinite, homogeneous and immovable container, which offers no resistance to the movement of the objects floating in it, a definition Euler polished with precision in the 18th century (Newton, 1983; Euler, 1911-1957). In 1914, Hausdorff defined "an abstract space" (it should be noted that it is no longer space but rather *a* space) as the network comprising any set of things and a sheaf of relations among those things (Hausdorff, 1914).

Despite being called "abstract spaces," in the 1950s a notion arose that the "space" sustaining them was not sufficiently abstract, sufficiently "clean", given that the structure of each of those spaces depended to a great extent on the nature of the specific things that formed the space. If its structure depends on the specific nature of the elements inhabiting it, a space is not really abstract. Moreover, if considered carefully and patiently, that space does not include the basic, primordial (topological, as we will understand further along) intuition of "space", something that is what it is, irrespective of what is in it





Velázquez, *Las meninas*, 1656 (Museo del Prado, Madrid).
Picasso, *Las meninas,* 1957 (Museo Picasso, Barcelona).

(Cartier, 2001). Newton's box with objects floating in it had been replaced by a network of networks, as illustrated by the paintings *Las meninas* by Velázquez (1656) and *Las meninas* by Picasso (1957).

Much changed in the realm of science and art since the *Principia* and *Las meninas* of Velázquez, until the *topos* and *Las meninas* of Picasso, and much kept changing since. In this article, we will reflect on some of those changes, especially in the last few decades. Since, on the one hand, it is a conceptual territory and, on the other, our only tool will be the written word, we cannot have recourse to visual images or cartographical representations. We will simply comment on several points and suggest some routes among them; not many, given that our aim is not to conduct a thorough exploration of the realm but rather to share some of the scenes we have enjoyed.

From the 17th to the 19th century, in what is known as its "classical period", the territory was characterized by the aspiration to describe the world as the eye sees it, and what "prevailed" were painting, sculpture, axiomatic mathematics and Newtonian physics. However, scientists and artists were aware of the limitations of their models and constructions and they continued to improve their tools, attempting to progress. About 1800 they began to position themselves on the surfaces of things, no longer considering them as sharp frontiers between things but as worlds in themselves. The intrinsic coordinates of Gauss, the non-Euclidean geometries of Lovachevsky and Bolyai (Gauss, 1827; Gray, 1982) and Goya's black paintings illustrate this way of working from the surface of things with no reference to a containing environment. It became necessary to develop new tools, and the astute tricks of the previous century (like Laplace's step-by-step iteration techniques to describe the planets' movements, or gradations of colour to represent volume in painting) gave way to constructions that were more precise and intuitive, and much more abstract.

Around 1850, many were ready to take the arduous step of granting themselves permission to "think differently". Berhard Riemann, Ada Byron and Paul Cézanne are excellent examples of this "thinking differently". In his research on the foundations of geometry, Riemann allowed himself — and, therefore, the mathematics and physics communities — to expand spatial notions

to objects beyond the realm of classical geometry and to conceive of spaces with arbitrary dimensions. By modifying Charles Babbage's machine with the aid of perforated cards — invented not long before that by Joseph-Marie Jacquard for mechanical looms — Byron transformed a mere calculating machine into the first scientific programmed computer, which she tested with a programme — the first ever (Byron, 1843) — so the machine would calculate Bernouilli's numbers. Cézanne, in his 1898 series on Mont St. Victoire, for example, used the two dimensional properties of the canvas as work tools, instead of fighting against them, to construct three dimensional volumes.

The process of developing new ideas was protracted and difficult and required a high level of abstraction (Corrales, 2000). Many of the concepts and notions forged along the way were based on radically new spatial intuitions, and they systematically changed the perception of artists and scientists, as shown in the work of the Impressionists and Cantor, among others. The definitive step was taken in the first third of the 20th century, when the first "abstract spaces", that is, spaces conceived of as networks of relations among things, were finally and explosively fixed and represented. Thus began what could be considered "the classic period of modern science and art", a short period between the two world wars in which all types of problems and questions arose, arguing against the classic distribution of the territory.

For example, despite the accumulation of discoveries and constant progress of the theory during the 19th century, the flaws in the foundations of Newtonian physics (Mach, 1942; Poincaré, 1983) and axiomatic mathematics (Nagel and Newman, 1958) were becoming increasingly clear. Moreover, the type of phenomena studied demanded new tools based on new concepts. For example, the need to develop topology became increasingly clear. It can be described as geometry where size and shape do not matter. Any map of the Madrid Metro — built in 1920 — available at the ticket office is an example of topology and its uses. That map — a topological object — portrays the physical reality of the network of tracks in only two respects: it shows the stops in order and the connections between lines. It ignores all the other details and does not show distances or directions accurately. Nevertheless, that is no problem to the passengers: the information they need when planning their routes — where to get on and off and where to change line — is available, given that the order of the stops and connections between stations are respected.

In any situation where the only relevant information is how many items there are and how they are connected, a topological model will describe the situation best. The map of any type of public transportation, electrical circuits, neural circuits, computer chips, telephone or Internet networks, and graphics that have been used — and discarded — since the 18th century to classify living organisms are examples of topological objects, which were systematically studied in the first half of the 20th century.

As is often said, following the Second World War and its devastating end in 1945 with the bombs dropped on Hiroshima and Nagasaki, "all that was solid dissolved into the air." That was the beginning of the "contemporary period", which continues to our days. Those bombs split the realm of art and science asunder. It had to be rewoven, its relations recomposed. Western culture plunged into a crisis that required new forms of relation and new ways of life, and in order to

relate to each other and live differently, we must begin by understanding what a relationship is and what types of relations are possible, as well as what life is and what types of life are possible.

Death and destruction served as incentives for studying life as we know it on our planet and other possible forms of life on other planets. Scientific research — which had not been Newtonian or Euclidean for decades — led by biology and sustained by increasingly powerful technology, turned to space. With the first human view of the moon, the same thing happened to artistic research and to the entire species, in fact. The arrival of the first photographs of the earth's taken from the moon and of the first images of the astronauts walking on a heavenly body with gravitational laws different from the earth's led society as a whole, and particularly artists, to join scientists and, leaving Newton and Euclid behind, cast their nets out into space.

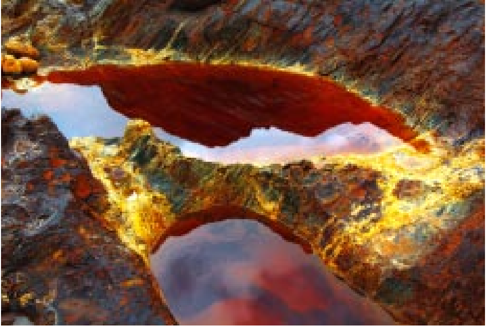
### The first photograph of the earth taken from the moon

The shift from working on objects, whether flat or three-dimensional, to working with the relations among those objects meant that dimensions, which had been a great concern for scientists and artists up to that time, lost their relevance. When we establish a network of relations among a collection of objects, we obtain a space that, in addition to being in another dimension, to make a play on words, is "from another dimension": apples and oranges. To mix apples and oranges without entering into a contradiction, one must create a more general category — fruit, for example. This type of issues, already manifest in works such as those of Russell, Wittgenstein and Duchamp, were addressed in the 1960s by space pioneers like Alexander Grothendieck and Robert Smithson. Space researchers essentially use a combination of two complementary methodologies. One is based on specific elements, builds various relational networks among them, and researches how to present the various resulting spaces in a comprehensible, coherent *topos*. The other consists of an interdisciplinary study of spaces — natural sites, for example — which are very complex systems of many relations among many elements. We will bring these reflections to a close with current examples that illustrate the simultaneous use of the two methodologies.

The projects of Smithson, from the USA, to recover former industrial and mining areas, where based in recycling the abandoned sites into aesthetic places by taking advantage of the natural activities that took place there. By changing our view on what are called "waste materials", ecology and industry were reconciled through art.

> Oxidation, hydration, carbonization, and solution (the major processes of rock and mineral disintegration) are four methods that could be turned towards the making of art. The smelting process that goes into the making of steel and other alloys separates 'impurities' from an original ore, and extracts metal in order to make a more 'ideal' product. Burnt-out ore or slag like rust is as basic and primary as the material smelted from it. Technological ideology has no sense of time other than its immediate 'supply and demand', and its laboratories function as blinders to the rest of the world. Like the refined 'paints' of the studio, the refined 'metals' of the laboratory exist within an 'ideal





Robert Smithson, *Spiral Jetty,* 1970.
Río Tinto, Huelva, Spain.

system'. Such enclosed 'pure' systems make it impossible to perceive any other kinds of processes than the ones of differentiated technology. Refinement of matter from one state to another does not mean that so-called 'impurities' of sediment are 'bad' — the earth is built on sedimentation and disruption. A refinement based on all the matter that has been discarded by the technological ideal seems to be taking place. [Robert Smithson, *A Sedimentation of the Mind: Earth Projects*, in Holt, 1979: 87.]

From New York City I called the Utah Park Development and spoke to Ted Tuttle, who told me that water in the Great Salt Lake north of the Lucin Cutoff, which cuts the lake in two, was the color of tomato soup. That was enough of a reason to go out there and have a look. Just beyond the Golden Spike monument, which commemorates the meeting of the rails of the first transcontinental railroad, we went down a dirt road in a wide valley.

Slowly, we drew near to the lake, which resembled an impassive faint violet sheet held captive in a stony matrix, upon which the sun poured down its crushing light. An expanse of salt flats bordered the lake, and caught in its sediments were countless bits of wreckage. Old piers were left high and dry. The mere sight of the trapped fragments of junk and waste transported one into a world of modern prehistory. The products of a Devonian industry, the remains of a Silurian technology, all the machines of the Upper Carboniferous Period were lost in those expansive deposits of sand and mud.

About one mile north of the oil seeps I selected my site. Irregular beds of limestone dip gently eastward, massive deposits of black basalt are broken over the peninsula, giving the region a shattered appearance. It is one of few places on the lake where the water comes right up to the mainland. Under shallow pinkish water is a network of mud cracks supporting the jig-saw puzzle that composes the salt flats. As I looked at the site, it reverberated out to the horizons only to suggest an immobile cyclone while flickering light made the entire landscape appear to quake. A dormant earthquake spread into the fluttering stillness, into a spinning sensation without movement. This site was a rotary that enclosed itself in an immense roundness. From that gyrating space emerged the possibility of the Spiral Jetty. [Robert Smithson, *A Sedimentation of the Mind: Earth Projects,* in Holt, 1979: 109.]






Narelle Jubelin, *Ungrammatical Landscapes*, 2006.

In Spain, in Huelva, there is also red water, in a river, not a lake, the colour of red wine, not tomato soup. Río Tinto, the river, is extremely acidic and heavy-metal-rich. For a long time, those conditions were believed to result from the pollution of centuries of mining in the area and considered inhospitable for life.

Ricardo Amils' interdisciplinary scientific team, which has studied the waters of Río Tinto since 1987, has proved that those conditions are not due to pollution but rather to the obsessive metabolism of micro-organisms that like to feed on pyrite (Amils, 2006). Those micro-organisms have unexpected ways of relating to each other that enable them all to survive in the river's extreme conditions, which they help to create and maintain. They feed on pyrite and transform it into minerals that look suspiciously like the ones found recently on Mars by NASA in the search for other forms of life. Research into the surprising activities taking place in the natural area of Río Tinto, many of them considered impossible until a few years ago, is causing science to reconsider some of its assumptions — which are culturally conditioned — as to what is life and what is not, what is pollution and what is not, and what is ecological and what is not.

In 1993, Ian Burn, the Australian conceptual artist, a writer and member of the New York branch of the Art & Language collective, died in an accident. Upon his death, as a tribute, Narelle Jubelin, an Australian artist based in Spain, initiated a series of "conversations" with Burn. One of them took form of an installation at the Centro José Guerrero in Granada in 2006. Jubelin took as starting point the legacies of José Guerrero and Ian Burn and she carried on a systematic investigation of them, in the process of which she kept establishing, more or less subtle but always lucid, connections between them.

She used these connections to spin precise threads — in the form of arguments, images, statements or suggestions — with which she wove an immense archive throughout the four floors of the centre, structured as a visual essay, both physical and architectonic. The *topos* Jubelin built with the legacies of an Australian and a Spaniard, who came to form part of the New York groups, Art & Language and Abstract Expression respectively, calls into question many of our conceptions — which are, as in the previous example, culturally determined — about the realm of art and knowledge: its constructions — galleries, museums, cathedrals, palaces or adobe huts — its movements, its centres and

peripheries, its empires and colonies, how relations are established — including the transmission of knowledge — and how creators negotiate and reflect these relations in their work.

Today's scientists and artists — with a great variety of tools at their disposal, free to move at will among them, and endowed with abstract structures rich enough to enable them to combine all those tools coherently in a sole description — are discovering realms that force us, as individuals and as a species, to reconsider what we have been culturally conditioned to believe is our place in the world.

Smithson proposed in 1970 that mining areas be converted into works of art; today, Amils suggests that the entire earth may be the scenario of obsessive mining activity carried out for billions of years by all kinds of micro-organisms. The transformation of our glance on the world that the work of them both invites to, calls for, taking a step further, transforming also the glace on the relations established among the different glances. Isn't that precisely what Jubelin's pieces furtively weave?

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# Culture in networks, network culture: emerging dynamics and economic policy

Pau Alsina

The appearance of information and communication technologies in practically every area of contemporary culture and society has fostered significant transformations as well as posing major challenges to be solved. Most of those challenges have long been present in our culture. However, they are more pronounced now, due to certain structural modifications that those practices contribute, which intersect with information and communication technologies (ICT).

The challenges we face today include the following: gradually breaking down the walls that rigidly divide knowledge disciplines, the result of a need to specialize, and the need to overcome the sterile division between techno-scientific culture and artistic-humanistic culture; erasing the distinction between an elite culture and mass or pop culture; modifying the relations of distribution among mass, official or institutionalized culture and alternative or specialized minority culture;[1] the increasing complexity of relations between public and private sectors; the extension of participation processes as carriers of value along with the apparent democratization of the control of the media; blurring the strict division between an active creator and a passive spectator or consumer; the diversification of intellectual property laws to make new hybrid options possible; overcoming the dichotomy of territorialized local culture and de-territorialized global culture; the transversal nature of cultural practices, as well as an increasingly interdisciplinary approach that is nourished by various knowledge circles; decentralization versus the centralization of cultural practices; or breaking down the rigid compartmentalization dividing industry, the university, public cultural institutions, and alternative or independent organizations.

If we understand culture as a process of production and exchange of significations, that is, a process of appropriation, negotiation and confrontation of significations, instead of a fixed set of practices and interpretations, then a concept of culture as dynamic instead of something essentially immovable that must be defended becomes obvious. Culture, understood as a dynamic system composed of flows of information, persons and products, takes on different forms in response to dynamic models of relationships among individuals, societies, and territories.[2]

If we consider diversity (of identities, agents, knowledge and contents) to be an active constituent of culture, then, without underestimating the difficulties this diversity entails, we must be aware of how positive it is and therefore, do everything possible to welcome and conserve it, caring for its equilibrium and sustainability.[3] Within this dynamism inherent to culture, concepts such as an “open cultural ecosystem”

enable us to understand the term *cultural diversity* in several ways, as promoting a balance among cultural agents of different sizes, the diversity of the cultural subsectors and agents, financial instruments, as well as a balance among sources, various genres and formats.

A diverse, interconnected ecosystem of cultural agents is the result of the growing complexity and interdependence of sectors. Thus, when we speak of connectivity, we are talking about the dynamics of connection among various cultural agents, at different scales, clearly in synergy with the concept of "cultural diversity." We are talking about a horizontal connection among various cultural subsectors (generating transfers, hybridizations or fertile contaminations that stimulate creativity and cooperation), and a vertical connection among all the entities in the chain of value and the agents of a certain cultural subsector, as well as a transversal connection among agents in the same sector and others, leading to authentically transversal pollination.

Nowadays we work in a *culture in a network* that cooperates at local, inter-municipal, metropolitan, national and international levels, where ICT play a major role as facilitators of that connectivity, a connectivity that should take place at different scales of the territory and should enable the construction of a local distributed network which also establishes links with international networks. At the same time, this connectivity naturally fosters intersections between science and technology and the arts and humanities as a strategy for cultural opening and innovation. Environments are created that enable connectivity with other areas of knowledge, as well as with industry, other fields of education and research, and communication spaces. [4]

The overall framework within which artistic and cultural practices today have developed is that of science and technology in a role of increasing significance, co-creators of ways of seeing what is real and living in our society. And we say *co-creators* because, beyond falling into scientific-technological determinisms that autonomously model the socio-cultural context, it would be better to conceive of an authentic co-production between technology and society, where the technological is socially constructed to the same extent as the social is technologically configured.[5]

The fact that our interaction contexts which sustain the social are comprised of artefacts, symbols, data or places means we must emphasize the active role of material culture in configuring the real. Recognizing the importance of materiality in culture does not prevent symbolic spaces from also being agents which structure that reality. Admitting that the media have technological materiality and also configure discursive matter is an expression of this double link between material subsoil and symbolic space.[6]

The complex relationship between science and technology shows the way in which theoretical discourse and material practices are interwoven. It has become undetectable and constitutes what has been called the *prevailing framework of techno-science*.[7] New instruments make new theories possible, mediated by those instruments. New theories make new instruments possible, which in turn, will make new challenges attainable. Technology and science mutually feed each other while interacting with society. Some artistic practices within this context aim to make explicit what is latent and conceptually implicit, which should be made visible in socio-cultural

areas inasmuch as they tell us something or quite a bit about the universe, the world and life.

Each historical formation sees and shows as much as it can based on its visibility conditions, just as it says all it can, based on its formulation conditions.[8] Likewise, artistic practices that make use of science and technology in relation to society, taking a certain technology as a starting point, exemplify and explain the extent to which that technology as a physical artefact has always been accompanied by that technology as a discursive formation.

We are talking about a historical framework encompassing a set of artistic practices which either fall within countless taxonomical categories classified by their technological foundations or remain on the margins of those categories, at the intersection of scientific and technological disciplines. We are talking about the relationship among art, science, and technology in society,[9] as "vectors of innovation" that have accelerated with the widespread introduction of ICT in many areas of human life. At this point, it is useful to mention discourses related to the collective mind about these techno-sciences and their appropriation and transformation by artistic practices that take them as a discursive basis for criticism — or inspiration — as well as the material foundations on which to build further developments.[10]

Relations among different disciplines, and increasingly among different circles, are produced today quite frequently as a strategy and dynamic for growth. New cultural agents should generate open environments and thus foster the creation of transversal interaction spaces that enhance innovation and creative processes. Innovation has become an open process with participation from industry, knowledge institutions, laboratories, independent agents and small initiatives of all types. Domains that were formerly separate are connected; therefore, transversality has become a fundamental catalyst of creativity and innovation. Open environments are encouraged where transversality among different persons, organizations and networks may arise naturally.[11] That is why environments must develop inclusive strategies for their current and future inhabitants, strategies that must take into account the new labour conditions of cultural workers, of whom a more proactive attitude is now required.[12]

However, this process dynamic makes it necessary to accompany the emerging cultural creation, facilitating its visibility and increasing its chances of gaining influence. Transversalities often expand their influence and, in any case, mechanisms are needed to accompany and strengthen these dynamics.[13] This process is becoming increasingly open, where citizens are both users and producers, creating their own goods, services and environments to the extent that they take control of the means of production, distribution and communication.[14]

The commercialization process of a large part of cultural production, understood as one of the key economic drivers in metropolitan areas, should not lead us to forget the remaining basic yields related to long-term cultural processes. In addition, the capitalization of creativity by multinational industries, especially of creativity arising from collective energy,[15] should be balanced by significant returns to the creators and citizens, to protect the diversity of agents and scales inasmuch as they are active constituents of culture as a whole.

A commitment to enhance a public creative space[16] with free access, open without limitations as to use, would be a decisive move, especially as an environment open to new agents and ideas, where diversity becomes a crucial element and a key factor in the emergence of new transversalities. That is why, in relation to the public creative domain, tools and resources must be made available to foster ongoing learning. Creativity is based on a system of ongoing learning and on the ability to explore new ideas and create new connections to turn them into realities. As users become co-producers of their goods, services and environments, they should have access to open production and distribution infrastructures.[17] This is particularly significant in the context of ICT and the generation of cultural contents and processes. Open knowledge systems are necessary, as are more flexible intellectual property systems in keeping with today's challenges.

Diversifying and adapting intellectual property to the new context is a key issue that must be carried out in depth, given the crucial role of creation in the era of the Knowledge Society. Options related to intellectual property should be diversified to offer new possibilities enabling an enhanced flow of the circulation of information and knowledge.[18] A case in point are open-source licences for software programmes, which can contribute significantly to facilitating creative production, education and research, to cite several examples.[19]

Throughout this text, we have outlined strategies, mechanisms and devices including a systemic vision of culture with its constituent diversity, ICT as catalysts for change, the inherent dynamic, open nature of the cultural ecosystem, connectivity between agents and scales in the network culture and a culture of networks, paying attention to the dynamics of creativity and innovation, new intellectual property models, and the need for a public creative domain and the generation of resources to enable ongoing learning. They can all contribute to facing some of the challenges mentioned at the beginning of this article.

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# The role of information networks in the evolution of social complexity

Pedro C. Marijuán

## 1. The evolution of societies toward complexity

One of the themes most discussed in the social sciences pertains to the s origins and evolution of social complexity. In this article we will explore how current studies of *networks* and certain discussions around the construct of *information* are opening new conceptual avenues toward the understanding of social complexity, including knowledge structures, which we ought to research in detail. By the way, it may be a sign of our times that there is an even greater interest in the “collapse” of societies than in their complexity per se (Tainter, 1989, was one of its pioneers).

If we take the work of Diamond (1996) as a starting point in regards to the social, it affords us a dense table that provides support for the argument of the *adaptive* nature of social complexity. This table details various features invariably shown by societies as they increase in

complexity. It consists of a series of social elaborations and institutions of great variety (kinship systems, labour divisions, exchanges, codes and norms, numbers, writing, religions, knowledge systems, legal systems, administrative and political bureaucracies, et cetera), many of which were clearly "informational".

Rather than associating them with a hypothetical "progress" of the social order, such elaborations must be understood as *adaptations* of the social structure to the possibilities offered by the environment. And one of the original factors that historically allowed mankind to go beyond their basic group size and structure — the hunting-gathering bands of about one hundred members — was the acquisition of knowledge toward the creation of artificial ecosystems: the domestication of plants and animals (agriculture and stockbreeding). The development of very different sets of foods, singularly marked by continental axes ("the axes of history") is what defined the relative strength of each of the geographical areas devoted to the production of food and the distribution of the corresponding human populations, along with their genes, cultures, languages — and even their germs! (Diamond, 1996).

When classical anthropology approached the discussion of the evolution of the successive organisational stages (of "progress") in terms of bands, tribes, fiefs and states or empires, or when more recently it adopted a newer perspective based on adaptation, it is worth noting that each organisational stage or gradation of the social system brought an increase in size of at least one order of magnitude: from tens to hundreds, thousands, tens of thousands, hundreds of thousands, millions of individuals. This is crucial in terms of networks. We could argue that each organisational stage brings forth a linear increase of the *diameter* (the logarithm of size) and a geometric increase of the *crossing speed* (the time associated to the diameter), both essential factors for the effective interaction of individuals within their corresponding social network.

The above would offer a new approach to understanding the correlations of social complexity. The emergence of new societies of higher complexity and organisation requires the development of informational systems for communication between individuals capable of covering the new social diameters, which are comparatively much larger, at substantially higher crossing speeds. Furthermore, these new relational tools would enable the emergence of multiple networks and sub-networks overlaying the basic fabric of social relationships, of variable complexity (harder to regiment hierarchically) and of equally variable duration, no longer limited strictly to the "strong" or permanent quality of family and kinship bonds characteristic of tribal groups.

In other words, the great informational and communications inventions that mark history — the alphabet, codes, seafaring, digits, the printing press, modern science, the steam engine, motor vehicles, computers — can also be seen as abstract tools for the articulation of multiple social networks and coalitions of a new kind, which partake in the deconstruction and reconstruction process of the existing social order by means of the heterogeneous types of "weak" ties that they foster, paradoxically with higher efficiency and with a broader range of action than the former so-called "strong" ties. Historically, what we here label as weak ties are constituted as authentic "bonds of civility" (Ikegami, 2005). Would the industrial revolution have been possible without the collaborative networks of modern science? Or the scientific revolution without the communication

afforded by books and other printed materials? Or the current process of globalisation without computers and the Internet?

The concept of the network is directly tied to the concept of information. Though some studies have already researched experimentally the role of information and of communication networks (particularly electronic ones) in the complex world of social bonds and ties, analysing the resilience, diversity and complexity of its emerging structures (Bohannon, 2006), this direction hardly seems sufficient. For many reasons, some of which we will present momentarily, the informational study of societies is in a most rudimentary stage (Howard and Schiffman, 1998; Marijuán, 2002), despite the fact that we are living in the *Information Age*.

## 2. What information is conveyed through communication networks?

A historical review of what was communicated in the Sumerian tablets, the Greek and Roman papyruses, or in much more modern media, would reveal an interesting coincidence. In any age, the unfathomable blend of "the human" is what permeates the social communications media. As McLuhan posited (1964), "the medium is the message." Media exist to contribute content to each other, to feed one another, starting from the basis of oral communication (though this is not their only primary source). Consequently, we cannot escape the problem of the "meaning" of all this circulating information, generated verbally and transmitted by the media, as McLuhan pointed out as well. We need a new conceptualisation or theory, beyond Shannon's physico-theoretical information and the logic systems of artificial intelligence, that permits the analysis of the "signification" or "meaning" of information as generator and vehicle of social relations, at the levels of both the individual and society.

### 2.1. The Basis of Oral Communication

What do we do, and seek to transmit, when we use any of the communication media? Language, as the epitome of human communication, is the fundamental vehicle for relations among individuals. The very use of language may be where the informational keys to our evolution toward social complexity lie. As a start, even a phenomenon as trifling and natural as a conversation between two people reveals numerous neuro-physiological curiosities. Speech constitutes behaviour with motor dominance whereas listening corresponds to a phase of sensory dominance; a significant alteration in the internal configuration ("in the super-system") of the brain precedes and mediates in the switch from talking to listening and vice versa (Collins and Marijuán, 1997, pp. 145-6). This transition should occur simultaneously and in opposite directions in both the speaker and the listener which, far from being assured, almost tends to work the other way round. This brings a remarkable degree of complexity into even the simplest human relations.

What happens as other people join the conversation is quite interesting. Each addition produces a qualitative change in the course and content of the conversation (its "chemistry") and increases the chance of breakdowns into subgroups of 2, which is most likely in groups of 5 or more (Dunbar, 2004). For even larger groups, general conversation is not feasible and it will break down into subgroups repeatedly unless principles

of authority or rank, or formal rules, come into play. The dynamic of small informal "circles", such as those that form following solemn receptions and acts, shows the same characteristics; they are even more evident in "restaurant conversations", when speakers cannot move from their respective positions.

Socially, it is noteworthy how many different ways specific oral communication settings have been organised, getting around the previous limitations and fragmentations through complex ad hoc restrictions that primarily affect the speech/listening transition mentioned above (from talks and colloquia in informal groups and associations to bureaucratic committees, academic classes, seminars, master lectures, assemblies solemn ceremonies, parliaments, etc.). In order for the specific communication function to survive, each setting must impose its own conditions regarding turns to speak, transitions, allowable times, language style, attitude, way of arguing, and so forth. Somehow, in the collective use of language we find ourselves repeating the communication problems inherent in the abovementioned stages of social evolution, and again the dynamic of restrictions and communications could easily be transferred to network patterns.

### 2.2. Language as a "massage" for the social group

In addition to its curious extensibility to large groups, spoken language has made another major evolutionary contribution. It is a real human equivalent of primate grooming, a type of cleaning or massage which is essential for resolving aggressive conflicts and for the cohesion of primate social groups. This is the main hypothesis proposed by Dunbar (2004). Small talk is not a relational trifle but rather a genuine psychological need for a "massage" that must be satisfied daily and generously. Quite possibly, this new type of group massage, along with theenigmatic additions of laughter and tears (and an impressive panoply of facial expressions), was the catalyst driving the explosive development of the human brain in its final evolutionary period, practically along with the increase in the basic social group (Allman, 1998; Bea and Marijuán, 2003; Dunbar, 2004).

According to the above, the problem of the *meaning* of oral communication seems to have been resolved over the course of evolution and has been diluted to a sort of generic "glue" within social groups. However, if that is true, language or proto-language is enhanced precisely in its trivial, everyday sense as a privileged means of making and breaking ties; of weaving and unravelling networks and coalitions within groups.

Specifically regarding *strong bonds* (the family group and relatives and very close friends), what oral communication achieves directly (or through substitute means through which oral communication can be channelled in complex societies) consists of *a systemic informational update related to other people's life cycles*, particularly everything related to their crucial "status changes." This is the deepest significance of unconditional maintenance of communication with the closest people (time and distance notwithstanding), regardless of the fact that it is inseparably linked to the daily dose of insignificant communication, even hidden behind it. In evolutionary terms, it is related to a propensity towards *inclusive fitness*, to adapting as well as possible to the environment and social milieu, integratively extending it to all those in the group with whom we share our genes. While

in *weak bonds* (which make up the thousand faces of social complexity), less significant aspects of these life cycles are updated, without entering into private, intimate affairs; or, more specifically, certain partial aspects are updated on the status of people's actions/perceptions with respect to rules, standards or averages of collective actions in certain social domains — the "data" social cooperation feeds on, especially in economic matters. Of course, at the same time, satisfaction of the daily need for small talk would be sought, provided that it was compatible with the greater personal distance that characterizes these relationships.

Social bonds or ties, which communication networks serve, are immaterial, "pure information" one could say, and reside exclusively in individuals' memories. How they are specifically updated depends, therefore, on the neuro-biology that served as a basis for those memories. In this respect, the creation and maintenance or breakdown of strong bonds are part of powerful emotional processes, while in principle, weak bonds are almost free, which means they can more easily be established, updated or broken. However, it is most likely that a wide range for neuro-biological configurations will have to be identified based on the heterogeneous nature of the bonds and behavioural situations (Collins and Marijuán, 1997). The recent discovery of neuro-hormones and neuropeptides such as oxytocin, vasopressin, and endorphins, which play an essential role in establishing different types of social ties, especially those of the nuclear family, brings microneuro-biology to the forefront of this discussion (Allman, 1998; Dunbar and Shultz, 2007).

Biological complexity can undoubtedly serve as a paradigm for essential aspects of social complexity — the way nervous and cellular signalling systems channel and integrate various types of signals that individual cellular cycles have to exchange with each other and with the global organism, at the rising and falling pace of informational processes (Marijuán and del Moral, 2007). In biological organizations and human societies, *communication networks serve to update signals of people's life cycles.* Collective, integrative solutions based on communication networks make the construction of global complexity viable, based on the fabric of interwoven lives, each of them encompassing its own informational complexity.

## 3. Information and the sciences: the integrative problem

In the two previous sections, we have argued that we construct communication networks not to exchange "empty" information but rather to fill them with a content that is almost homogeneous, given that it refers to the updates of the various mental models we have of the people who interest us, their life cycles in relation to our own, and the course of their everyday lives. That is what hundreds of millions of "worried" mobile calls check up on hourly, just like the recently discovered texts in waxed tablets that Roman legionnaires were regularly sending to their families from their remote fort at Vindolanda near Hadrian's Wall (Fischer, 2001).

This homogeneity was shown to be transparent or empty in the pioneering analysis by McLuhan (simply, "the medium is the message"); but was indirectly recognized in his idea of "the global village". If we are lacking a group in which we can participate in the social massage, why shouldn't the media provide us with a comparable cast of fictional characters and lives (and reality shows), in a sort of natural basic group, apparently

within our reach, as a substitute or complement to the dramatic scarcity of relationships and strong bonds in the heart of a complex society. In the Information Era, it is easy to multiply the substitutes technologically, although they are increasingly less useful.

There are many subjects to be addressed to advance toward a new overall view of information in human societies (one expects a "socio-information" discipline within a broader "information science"), too many aspects to synthesize… In the rest of this article, we should address, or at least discuss briefly in no particular order, in a sort of quick essay, three major aspects:

First, the need for a new type of "theory of the mind" which through a different "informational" approach to central nervous system processes is coherent with an integrated scheme of information flows in living beings' cellular and molecular organization. Specifically, we must transcend the modern and post-modern conventional concept of the mind as a *tabula rasa* free of determinants to develop any kind of learning, way of life, culture, social order, etc. Human nature exists, and can be defined in genomic and neuro-informational terms. The apparent "automation" in the acquisition of our knowledge does not mean that it is de-materialised or "debiologised". In this respect, the thinking of K. Collins (1991), related to the "imbalance" or collective level of incoherent excitement as a neuro-computational guide for the nervous system's sub-systems to correctly adjust the adaptive motor/sensory behavioural responses to the environment, offers an important contribution to the debate (Collins and Marijuán, 1997). Moreover, an underlying idealism exists in relation to the preceding subject derived from a consideration of *concepts* themselves, postulated as efficient beings that are also completely abstract, which again lack any limitations or neuro-biological determinants (Berthoz, 2000). In this respect, the "cognits" of Fuster (2003), which can be translated as *cognitions*, are of great interest to connect the conceptualization abilities inherent to language with the neuro-biological realities — and the "imbalances" — of the action/perception cycle upon which animal and human behaviour is organized. Language, quite predictably, is built on a common basis of motor processing with unusual symbolic and syntax capacities made possible by new cortical regions with properties similar to those present in "mirror neurons" (Arbib, 2001). In neuro-informational terms, cerebral processing as a whole is biased toward vital action, toward generating adaptive behaviour.

The second subject is the discussion of the collective knowledge system of society (as represented in the "maps" and relational networks of the sciences) along with the role that information plays in the overall interrelation of the sciences. Everything is relational in science, characterised by mediation: communities of disciplinary agents; the networks of relations (and citations) among works; the very close interrelation with technology; standardisation and mathematisation… and what is mathematics itself? We are witnessing the emerging praxis of a collective nervous system, a genuine social actor and "sensory system." The *scientific method* represents the conditions for the actual breakdown of cognitive problems among research communities, as well as for the social organization and distribution of the knowledge developed. Like the rest of society, albeit more intensively, science has kept pace with decisive informational advances: writing, numbers, alphabets, logic, algebra, monasteries and universities, clocks, the printing press, "self-acting

machines", computers... Since the First Industrial Revolution, the system as a whole has doubled with each generation (researchers, scientific fields, publications) and the social accumulation of knowledge has accelerated at a practically continuous rate. This constant historical increase can be visualised with today's "geography of science": realistic maps of disciplines, based on citation structures from the Citation Index, which can be viewed from the level of authors and specialised fields to global maps (Small and Garfield, 1985, were the pioneers). Each modern generation has witnessed the appearance of an increasing number of scientific disciplinary and interdisciplinary fields of all kinds (from about 3,000-4,000 in the 1960s to about 8,000 at present). This rise in scientific complexity is parallel to that of society and its technological, economic and cultural complexity which makes it increasingly difficult for educational systems to make the syntheses they must carry out. This is the traditional "dilemma of specialism" (Ortega y Gasset, 1930, 1933), which in our day has reached the social system of knowledge as a whole and its interrelationship with economics. The greater the separation in the natural base of ecosystems, the greater the complexity in the network of informational mediations between social perceptions and actions, and the more specific knowledge must be incorporated into productive processes of all kinds. However, the lack of a unifying perspective on the various informational dynamics makes it very difficult to go beyond clichés and mere pragmatism as far as the interrelationship of societies with the accumulation of knowledge led by the sciences.

And third, the classic debate of "reductionism" should be re-examined, in this case as opposed to "integrationism" (setting aside once and for all the outdated ideas of "holism" and "systems theory"). The integrative problem in the sciences (and its links with the economic, political, social and environmental) is so significant nowadays that it cannot be exaggerated: globally, the very *sustainability* of society, the survival of civilization, is ultimately at stake. The conventional approach to the problem of how disciplines relate to one another has been and continues to be the big reductionist scheme based on a hierarchy among successive levels of knowledge. That translates to the "imperialism of physics" (with mathematical, mechanical statistics, classic, and quantum physics at the top). However, when examining in greater depth the project of a general reduction of the disciplinary strata, what emerges is a blurry image of scientific practice. To what extent do fundamental disciplines correspond in their hierarchy to the successive levels of aggregation or decomposition of matter, as reductionism implies? In practice, a massive interpenetration among the sciences is the product: all kinds of levels of vertical overlap, along with numerous horizontal integrations, that emerge throughout the entire system of knowledge. It is the closest thing to a global ecology of knowledge domains, as can be seen on current maps of relations among the sciences. The main problem is not the "reduction" among disciplines but rather the convergence and *integration* of multiple specialised fields: an unsolvable integrative problem, on the individual and group level. We are slaves of "limited prehension." No logical keys exist within disciplines to indicate when we should change discipline or turn to a different knowledge community. It also implies a problem with the prevalence of perspectives: the risk of making an error with respect to the view or perspective that should prevail at a given time or in a certain situation. There are multiple possible ways to act in the "multi-

disciplinary theatre", in the *perspectivism of the praxis* that individuals and groups are involved in. In fact, the endless mix of disciplines and sub-disciplines in the oral communication of science, in classrooms, seminars, conferences, meetings, and lectures is an interpersonal manifestation of that perspectival problem on the global scale of the sciences and the integration needed along with the other activities and settings of social life.

As made explicitly clear in the celebration of this "banquet", multi-disciplinary dialogue forms part of the very nature of intellectual collectives. It is the art of knowledge exchange, the art of knowing how to capture and arouse a person's interest, excitement and creativity. It is the most valuable influence of advanced educational systems. Herein lies the eternal appeal of science.

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# Infotechnology: new social forms, digital noometamorphosis and noomorphosis

Fernando Sáez Vacas

The amazing evolution of technology, ruled by information, is an incubator where, to give several specific examples, we have witnessed the birth and development of electronic mail, medical tele-assistance and e-learning, as well as various forms of cyberspatial communication, such as the immensely popular social networks and blogs. Most importantly, it has transformed our way of life, including the mental processes that govern our daily lives and view of the world. This is the result of the *co-evolution of humanity and technology*.

## The technological power of infocitizens

Infotechnology users spend an increasing amount of their time in what could be called the *infocity*, which I defined[1] at the end of 2004 as "The informational space where humans in developed societies, through terminals with buttons, keys, screens, passwords and various identifiers, communicate and carry out an increasing portion of their habitual activities and many new ones, converted into signals, symbols, languages and immaterial processes, based on a powerful technological infrastructure with reticular architecture."

This infocity coexists with the city, though often in conflict with it, complementing, transforming, broadening or replacing it, as the case may be. It depends on technology, our artificial prosthesis, or to put it more radically, the infocity exists in and through the technological prosthesis, from which its power and fragility arise, as well as all of its manifestations. They include blogs,[2] a new section of the repertoire of infocity communication activities, a lively section with its own personality on the Web, a virtual subspace[3] based on a powerful technological infrastructure that becomes more like a Universal Digital Network with each passing day (Sáez Vacas, 2004b). Many people seem to believe that things spontaneously spring into being, and thus, it is worth pointing out that we are discussing the product of a complex sociotechnical and cultural process, with a time sequence of maturation. It serves to take any modern technology from an embryonic infrastructural state to the stage where it is converted into a useful tool, to be subsequently appropriated socially by part of a high number of final users. The majority of them are unaware that they are citizens in a space that never existed until now, and possess a great capacity for personal action, as we enter a new social, mental and ethical ecology.

In that process, a leading role has been played by the personal computer, which is the historical instrument comprising the user's power — the user's personal infrastructure par excellence — that has evolved by leaps and bounds. Initially, they were provided with a bare operating system, solely apt for programmers and very technically

skilled users, until, with time, personal computers gained a highly intuitive graphic user interface with many practical applications that made use of the amazing data processing and memory features foreseen by the Moore's famous law of microelectronic progress.

### Metamorphosis from professional infotechnology to social "machinery"

Without going into details, today everybody knows that a computer is a universal machine, able to carry out — thanks to the proper *software* — all types of data processing, not only in numerical or calculation fields, as was true of its origins, but also texts, graphics and images, signals, symbols and languages, etc., separately or jointly, forming multiple combinations, capacities that have expanded and been included in all instruments and digital information appliances. The most spectacular example is the digital terminal we take everywhere we go and continue calling a "mobile telephone" out of habit. We have reached the era of technologies for everyday life, which can be abbreviated in Spanish as "TVIC."[4] However, to complete the list of types of processing, an essential point is its capacity to become a node of communication networks, a technological matrix where the definitive step is underway for today's social information revolution. From the perspective of economic sociology, looking back to 40,000 years B.C., Wood (2000) has shown that the developed nations are in the sixth wave (from 1975 to 2010), corresponding to the network revolution, thanks to the convergence of telecommunications, computer science and communication media, which is not, as is often written and said, limited to the Internet.

A dense fabric of interoperable networks has emerged and is growing. Its structure of nodes formed by computers also includes many devices, including the super abundant telephone, which now incorporates the legacy of multiple information technology features in a one-hundred-grams terminal: email, SMS and MMS messaging, camera, radio, MP3 player, calculator, calendar, clock, Bluetooth and Internet connections, GPS land navigation, etc. In sum, the development of infotechnology has produced a huge social machinery as a combined effect of two historical processes, which can now be summed up with two of their fundamental contributions: *a*) based on the invention of the personal computer, the development of abundant and varied useful applications for millions of final users in economically developed countries who, with more or less effort, have overcome the digital gap or, due to their youth, never experienced it; *b*) the progress of the connectivity properties of the set of digital devices, that transversally connect all the users, their data, ideas, information, process resources, through new applications for networks and various platforms, with the Web outstanding among them due to its great popularity, the simplest, most universal vehicle for communication and surfing for a huge and highly active reservoir of information.

The leap has been immense. To describe it briefly, the capacity[5] has been transferred from the huge computers in data processing centres of the 1960s and 1980s, governed and operated exclusively by professionals and which users, with no direct access, perceived from the base of the pyramid in a passive relationship, to a desktop or laptop computer, with which those hundreds of millions of users can operate autonomously in communication with other users and their machines, not one on one as a telephone network,

but one to many, or potentially everyone to everyone. Thus, each and every one of the user-nodes would have the capacity to become the centre or a node in one or several of the copious and almost intangible social networks formed in the infocity, with growing dynamism and density, thanks to the development of a broad range of cooperation technologies.[6]

The transformative power of technology has given renewed vigour to the study of social networks, now transmuted into an interdisciplinary field that encompasses anthropology, sociology, social psychology, history, political science, human geography, biology, economics, communications science and other disciplines. The structure of social networks was a widely researched subject in the 1960s, in the wake of much earlier mathematical work on graph theory, but only quite recently has a new science of networks been proposed (Barabási, 2002). I have long thought that the broad notion of "network" has become a truly general conceptual paradigm (Sáez Vacas, 2004a).

### A time of social learning and a dense (technological) time

As stated by Winograd and Flores in a book that has yet to be surpassed in its genre: all technological tools are part of a complex social network (Winograd and Flores, 1986); the significance of a new tool lies in how it is incorporated into that network, modifying it; and, to understand a technological tool, it is not enough to gain a functional understanding of how it is used. One must also gain an overall understanding of the technologies and activities involved. And we should add: and of the consequences, which are not always benign and are at times pathological, as can happen when an imbalanced development of the infocity turns humans into "data processors and packages" (Sáez Vacas, 1991).

All the technology of the Internet, or, in a broader sense, of the Universal Digital Network, makes the time of action more intense, denser (a concept described by Rosnay, 1996), or, to state it simply, multiplies the number of each user's activities per unit of real time, a feature that, as just stated, may involve consequences that are not only positive (Sáez Vacas, 2004b: chapter 11) and which, in view of the set of emerging changes, lead us to suggest it might be wise to develop a sociotechnology for the whole set and some technocultural bases suitable for these circumstances (Sáez Vacas, 2008).

In contrast to dense time, social learning of technologies takes place in "long time" processes (concept proposed by artist Laurie Anderson). Basically, the feats achieved by technology, due to its complexity and because it changes much faster than humans, are not automatically taken into the working and dynamics of social structures. In principle, any complex technological product — let's take email, invented in 1971, as an example — needs to evolve over several generations until, following a maturation process, it achieves, with the experiential aid and contributions of a minority of users some quite technical, others quite enthusiastic and innovative, a sufficient level of usability to reach a broader public. And that significant operative leap, materialized in the social appropriation of dense time, opens the door to an opportunity to develop the changes — that are cultural, political, economic, and so on — typical of all historical processes of technological innovation.

It may bear repeating that merely assimilating the operative aspects (in reality, never more than a fraction) of any technology — or tool, if one

prefers — is one thing, but gaining an understanding of its social significance, how it modifies the conditions of our way of life and behaviour in multiple dimensions, and learning to use it efficiently and with common sense, quite another. That is the gist of the second phase of social learning of technology, given that, as biologist Dobzhansky was correct in asserting, "Upon changing the world they live in, humans change themselves." And that cannot be left to improvisation.

Social learning levels are not uniformly distributed among the population of users. Only a minority of trained, aware users — that should include those of us who ask questions, innovate and set patterns for others to follow — will attain a certain familiarity with the concepts and techniques hidden behind the simplified interfaces of socialized technology, or its transforming implications, or the deeper meaning of "the technologies and activities involved", but not, unfortunately, of the three disciplines at the same time. The remaining users, that is, the immense majority, operate more or less automatically, guided by only a bare minimum of functional technicality, similar to that of a driver using all the buttons, indicators and screens in a car, which are equivalent to the buttons, icons and forms one finds today on platforms to publish and edit blogs. It is only a slight exaggeration to say that all one needs to know is what button to press, where to click, or what menu to bring down with the mouse.

However, if, in addition to our fascination with the ineffable, purely material achievements of technology, we believe it to be an instrument of positive social change, we should reflect with greater attention in our attempt to understand how its features and properties create a general environment that establishes the operative conditions of our activities in the infocity and our relations with nature. I took this advice and wrote a book of my personal reflections (Sáez Vacas, 2004b), focused on the set of digital technologies, and the Universal Digital Network *(la Red Universal Digital) (RUD),* a reticular structure that penetrates into the core of objects and human bodies. The RUD projects a way of life onto the human environment comprised of at least twenty transforming conditions and forces,[7] that I call the "New Technosocial Environment", in Spanish *Nuevo Entorno Tecnosocial* (NET), where new social forms in the infocity and a new "culture" are developing, in competition with the classic forms of the city.

That culture is due to a large extent to the digital nature of information, which now encompasses in a sole aspect all the dimensions of multimedia and all known types of processing, and turns them into a universal, repeatable (and therefore inexhaustible) structure that is "infinitely" versatile, able to instantaneously be and move into every part of an open, incommensurable and invisible space (except to the eyes of the technological prosthesis of each node), which theoretically belongs to no one and belongs to us all, in which we are all called to take part.

An "infinitely" versatile universal structure? Solely with respect to access to information, the following paragraph, not to mention the title of the article by Kelly (2005) from which we have excerpted it — "We are the Web" — gives us an idea of that type of versatility:

> Today, at any terminal of the network, you can have access to an amazing variety of musical and audiovisual contents, an encyclopaedia with its own voice, weather forecasts, classified ads, satellite images of any place on Earth, "instant" news from the entire planet,

forms to pay income tax, TV guides, marked highway maps, stock market quotes in real time, telephone numbers, real estate catalogues with virtual views, images of almost anything, sports results, sites to buy practically anything, lists of political contributions, library catalogues, manuals for all kinds of devices, live traffic updates, archives of the major newspapers, and everything organized on an interactive index that really works.

## Emerging social forms compared to social forms in decline

The relations between the city and infocity generate a permanent crisis zone in which social learning takes place. This must include facing the creation of new activities and the transference of activities in classic "city mode" to the new environment (Echeverría, 1999), "infocity mode", given that, as we have said, the infocity, where users tend to acquire an increasing functional power, integral to the new technosocial scenario, complements, broadens or replaces the city, which, in other words, means that social forms tend to change. For example, the way journalism is performed, the way things are bought and sold, the ways music is distributed, the ways things are published and managed, how politics are run, ways of educating and learning, how people get their information and news, the ways people commit crimes, etc. As a result, the human organizations that support those activities change. Although history has amply demonstrated that completely opposing the forces of technological innovation is not a winning strategy, it has also shown that it is normal for numerous human organizations, rooted in declining and possibly replaceable forms, tend to resist, or conflicts are produced in areas where change is still poorly defined or where there is a loss of certain privileges and consolidated power of control.

At this point, I would like to make a clarification. In none of the lines of this article have I attempted to identify directly the unquestionable technical power placed in the hands of the infocitizen in this new emerging technosocial environment, with personal or social power, where that means the ability to control or influence others, although I think it is legitimate for other authors and analysts to highlight this characteristic as compared to the other established forms of political, economic and media power of some organizations or, for example, to speak of techno-influencers, in relation to the economy and markets.

However, it is worth pointing out the explosion of forms of collaboration among infocitizens, attributable to technical development. Upon consciously incorporating it into their lives, users can contribute, and many do, to building a more active, more creative infocity where more is shared and the flows of exchange are less pyramidal. Kelly (2005) speaks of an emerging culture, based on sharing, including blogs, wikis, open source, P2P, etc. Millions of persons who were formerly merely receptors, have already become very active participants, and some are co-authors or co-producers of various social networks, frequently with no personal economic gain; according to a study quoted by Kelly, only 40% of the Web is commercial.

## A subject for debate: the impact of digital technology on our mental processes

Earlier, we referred to the need to try to understand how the features and properties of infotechnology create a general environment

that determines the operative conditions of our activities in the infocity. Now, we must extend the understanding of that impact to our cognitive and emotional processes. Infotechnology, directly or indirectly, can be considered a knowledge tool and therefore, a tool for intelligence and culture. As explained by R. Simone, it influences how our brain handles information, how information is received and processed, how it transforms the capacity and weight of our senses in the formation of knowledge, and how it activates new modules or functions of the mind (Simone, 2001).

A lack of space prevents me from offering a detailed description of this highly significant matter in terms of the social and personal relations in life without defined borders between the city and infocity, a subject of great importance to education, which is why I will end with an overview of two aspects referring to possible changes in the structure and dynamics of mental processes.

One is particularly related to children who have been called "digital natives", given their intense early immersion in the increasingly dense and extensive infostructure we are calling the *Universal Digital Network*. In 2006 on a blog, I proposed the hypothesis of the "change in mental structures and therefore, in the very form of intelligence of a rapidly growing number of our kids", a phenomenon that, based on the Greek etymology (*noos,* 'intelligence', and *morphosis,* 'formation'), I christened as *digital noomorphosis*, which means 'formation of intelligence' (Sáez Vacas, 2006).

If social observations and neuroscience experiments confirm this hypothesis, human relations, education, political and economic organization, communications, the very concept of "human being", etc. will undergo a radical shift, given that intelligence is the true measure of a human being. Digital noomorphosis is where the real, huge dimension of the digital divide is hidden, a concept that we have handled to date with extreme superficiality, if we assign the true value to its connection with a new social, mental and ethical ecology.

It is not that the intensive use of RUD technology may contribute to moulding greater or lesser intelligence — for example, to making children cleverer, as some say — but that it results in a functionally different kind of intelligence, that is, equipped with specially developed capacities to live and operate in a new technosocial environment (NET, in its Spanish acronym) generated by that technology. Given what we know today about intelligence, the habitual discourse about IQ (intelligence quotient) to quantify it no loner serves in emerging situations, which is why some say that it will not be long before IQ may become practically a relic, like so many other social forms in decline, including educational systems. Logically, digital natives tend to be the natural inhabitants of the infocity, which is why they will potentially be equipped with many of the capacities suited to the immaterial processes that are typical of it.

To complete the picture and not restrict ourselves to children or new generations, the second aspect we need to reflect on is the influence of infotechnology on the minds of "digital immigrants", that is, adults of all ages who have to adapt to spending part of their time living in what — for them — is unknown: the infocity. Naturally, their minds also adapt, as suggested by several examples from everyday life, compatible with the feature of brain plasticity. Recently, a media debate arose based on a text by Nicholas Carr, in which he confesses that the intense use over the span of a decade of the Internet in general and on Google's search engine in particular are causing him "the uncomfortable sensation that someone or something has been playing with my brain, changing the layout of

its neural circuits, reprogramming my memory"; in a word, changing his thought processes. To name this type of transformation (metamorphosis), I created the term "digital noometamorphosis" (Sáez Vacas, 2008).

There is work here for neuroscientists, for although Carr titled his text "Is Google Making Us Stupid?",[8] it is already possible to quote professor Gary Small of the Semel Institute for Neuroscience and Human Behavior at UCLA (University of California, Los Angeles), who, in contrast, through recent experiments with mature and elderly adults, has shown the positive influence of search processes on the Internet on the decision-making and complex reasoning functions of the brain.[9] Dr. Small has also written a book titled *Ibrain: Surviving the Technological Alteration of the Modern Mind*.

All of these effects, still not understood to a large extent, are some of the results of the historical process of the "co-evolution of humanity and technology."

**Notes**

**1** "Ya portamos en nosotros los terminales de la infociudad", lecture at the International Congress on Digital Culture and Citizenship, Universidad Autónoma de Madrid, 15-19 November, 2004.

**2** I coordinated a monographic collection of nine articles on this subject, published under Creative Commons licence, in the journal *TELOS* (Sáez Vacas, 2005).

**3** In an interview published by the newspaper *El Mundo*, 3-12-2004, Tim Berners-Lee, the inventor of the World Wide Web, defined it as "a collaboration space in which to communicate and share information." In this article, we have called it a *subspace*, with reference to the total space comprising the information provided by the Internet and the Universal Digital Network in general.

**4** Acronym proposed by the author (Sáez Vacas, 2007).

**5** Recent technical data from official reports issued by the U.S. Semiconductor Industry Association show that an electronic memory chip has an approximate capacity of 75 Mbytes, included in a small square of 310 square millimetres and the microprocessor of the most recent generation of personal computers can execute several hundred million machine instructions per second.

**6** On this subject, see reports SR-897 *Technologies of Cooperation* or *The Cooperation Project: Objectives, Accomplishments, and Proposals*, at <http://www.iftf.org>, the web site of the Institute for the Future, in Palo Alto (California).

**7** Transformations or barriers classified in five space-time dimensions: *a*) transformations; *b*) transformations in the body itself, in sensory relations, in the limits of personal action and in identity; *c*) transformations toward a unified language for data capture and processing methods; *d*) transformations in hierarchies of intellectual relations with the technological environment and objects; *e*) barriers in relations between users and technology (Sáez Vacas, 2004b: chap. 10).

**8** N. Carr, *The Atlantic,* <http://www.theatlantic.com/doc/200807/google>.

**9** See R. Champeau, "UCLA Study Finds that Searching the Internet Increases Brain Function", <http://www.newsroom.ucla.edu/portal/ucla/ucla-study-finds-that-searching-64348.aspx>.

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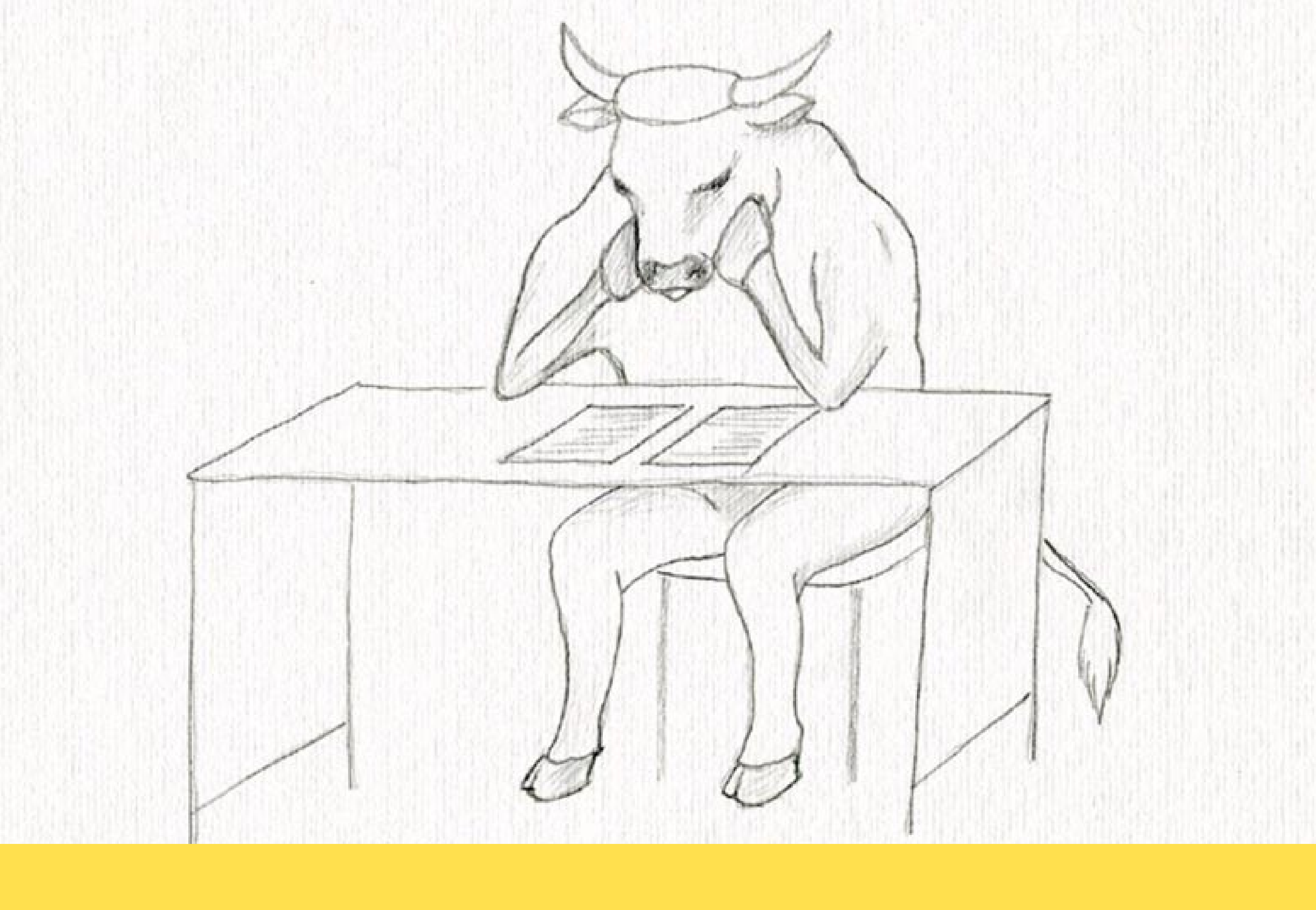
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MISTERIO DE
EDUCACION



MARTA DE GONZALO AND PUBLIO PÉREZ PRIETO
***The Intention***, 2008

Marta de Gonzalo and Publio Pérez have developed an artistic discourse linking their production to educational practices; that is, they have established as a premise that the artistic function is, in itself, a *form* of education. This outlook is based on the fact that all aesthetic experience constitutes a crisis in the face of an unsatisfactory reality, and that each individual's Utopian thought provides the only liberating possibility in the face of the managed world. The production of tools for an alternative awareness thus becomes a priority, to construct a subjectivity not determined by the assimilation of archetypes derived from the economic system. Such universal premises come into direct confrontation with individualizing atomization and relativism. They are situated, incidentally, outside the artistic circuit as a guarantee of corporative and essentially aesthetic recognition, and break with a model of artistic autonomy that, despite its transvestitism and pretence, does not escape from its modern legacy.

*The Intention*, therefore, aims to be both an applicable educative project and an artistic project. Given the nature of its *mise en scene,* it encompasses various formats and discourses, and is shown at exhibitions as a series of four videos screened at school-desk shaped wooden structures, with an accompanying set of drawings and prints done on paper or right on the wall. The content of the videos is an extensive series of voice-over narrations over a montage of images including interviews



and fragments grouped by subject, from childhood, adolescence, and adulthood to old age. The project is completed by a book that aims to serve as an applicable manual in the real educational work of teachers at different stages of education. The audiovisual device is not only presented with the exhibit; instead, it circulates with the book as material that can be used in various educationally oriented settings.

The preparation of an alternative “textbook” would be a focal point of resistance going back to the origin of the knowing-seeing problem, to a sensitive understanding of reality, in epistemological terms and its political dimension, from which it is inseparable. The epicentre of political action that can contribute to artistic discourse therefore seems to lie in a reinvention of educational strategies.

The approaches taken by Marta de Gonzalo and Publio Pérez are linked to a tradition of the historical *avant garde* oriented toward the transformation of awareness through art, but they do so from a new media context where aesthetic awareness is determined by audiovisual codes. In fact, they reinterpret the function of art in a context in which symbolic traffic and the industries of subjectivity go beyond former concepts of propaganda. In this new reality, the notion of audiovisual literacy lies at the core of the works based on educational experience. Their own work as educators thus lends meaning to the need for their work as a response to the lack of protection the system fosters and forces them to find a way around the ideological risks of dogmatism that already proved stumbling blocks to *avant garde* projects of the past.

**V.R.**


a v i d a t o d a h o r
QUARTZ



Un hombre/ una mujer recita en voz alta
todas las historias del mundo.
Cuando haya terminado, todas las historias,
todos los hombres y todas las mujeres,
todo el tiempo y todos los lugares
habrán pasado por sus labios.

Todas Las Historias

<< Insertos en Tiempo Real

DORA GARCÍA
***All the Stories***, 2001-2009

*Todas las historias (All the Stories),* private stories, in the public environment of the Internet. As a on-line "work in progress" of participative narrative, Dora García's work is a file of micro-stories posted on the Web, always open to new contributions. Infinite. Thus, endless. Because she wants "all the stories" and, with them, all the names, like those Saramago sought in the huge, never complete memory file. And there, in the space given to them by the artist in a remarkably poetic work that is also participative, they overlap, relate to and dialogue with each other and with us, the users, who, curious and amused, hear something more than what we are literally reading.

The answer lies, then, in language, but more in the subtleties of language than in what the stories actually tell. As José Luis Pardo states in *La intimidad* (Intimacy),[1] words can be used to refer to things with no need to speak (as parrots, speaking machines, some politicians, and advertising technicians do), but those who know how to speak do not consider one word just as good as another. They don't sound the same. Because it is almost impossible not to notice that, in addition to saying something explicitly, words always mean something more, something that slides in like contraband, that speak (or try to speak, because one also must know how to listen) without saying it explicitly, unequivocally, but holding it inside them. Because intimacy, and here we are speaking about intimacy, is an effect

1- Un hombre recita en voz alta todas las historias del mundo. Cuando haya terminado, todas las historias, todos los hombres y todas las mujeres, todo el tiempo y todos los lugares habrán pasado por sus labios.

2- Un hombre sueña toda su vida el mismo sueño. Incluso cree que en realidad está viviendo dos vidas, la una interrumpiendo la otra según duerme o se despierta.

3- Un matrimonio tiene cuatro hijos cretinos. El hombre quiere tener otro hijo, deseando desesperadamente un heredero para sus tierras; la mujer prefiere morir antes que traer otro ser incomprensible al mundo.

4- Un hombre se despierta como último habitante de la Tierra, el planeta habitado solamente por soledad.

5- Un hombre decide darse un paseo. Un paseo infinito, sin propósito, sin dirección alguna. Lo deja todo y se va, y camina, del amanecer hasta la puesta de sol. Se encuentra con todo y con todos, en este paseo inmenso al que considera la forma más perfecta de conocimiento.

6- Un hombre diseña un interuptor que le hará vivir o morir según lo encienda o lo apague. El hombre pasa el resto de su vida inmóvil, contemplando el interruptor.

7- Dos muchachas adolescentes comienzan una relación lésbica asfixiante y peligrosa. Cuando sus padres intentan separarlas, ellas deciden matarlos.

8- Una mujer sin ninguna importancia confiesa un crimen que no ha cometido en un intento de atraer algo de atención del mundo hacia ella.

9- Un vigilante se encuentra con un dilema cuando su hija se enamora del prisionero que vigila.

10- Una mujer joven es obligada a casarse con un hombre viejo, pero no puede olvidar a su primer y verdadero amor, y sigue pensando en él cada día de su vida.

11- Un juez debe decidir si un asesino está loco o sólo lo pretende.

12- Una mujer vive una vida de sueños rotos.

13- Un hombre, tan completamente dominado por otro hombre, que su vida entera es controlada y decidida por él. Cuando su dominador muere, lejos de sentirse libre por fin para vivir su propia vida, nuestro hombre siente una soledad y un desamparo infinitos, una angustia cuyo único alivio sería la muerte.

14- Una mujer se enamora de un asesino. Ella está convencida de que su amor puede redimirlo, liberarlo de su tormento interior, que es el que lo empuja a matar. Pero ella no puede salvarlo, y él la asesina.

15- En el año 2001, una expedición descubre un hostil cerebro extraterrestre que puede convertir los pensamientos en realidad.

16- Un niño ve cómo unos extraterrestres aterrizan en el patio trasero de su casa, y abducen e hipnotizan a todos los adultos del pueblo donde

of language. When it lacks that inner resonance, language is no more than artifice and chatter. We usually understand the word as a finished state of thought that is lost when externalized. It seems, on the contrary, that Dora García understands the word as an active force enabling different intimacies to see us and speak to us from the Web. Each of these stories is calling to intimacy from the moment in which, though we are barely aware of it, various emotions become tangible with no need to name them directly. In the end, it will turn out to be true that the last discourses of intimacy are hidden in artistic language. Artistic discourse allows us to “savour” the intimacy of the person who speaks to us (even when the stories are as short as these are) without violence, without dirtying, publishing or publicizing it. Simply and mysteriously, it is communicated.

**Y.A.**

1 José Luis Pardo: *La intimidad,* Pre-textos, Valencia, 1996.

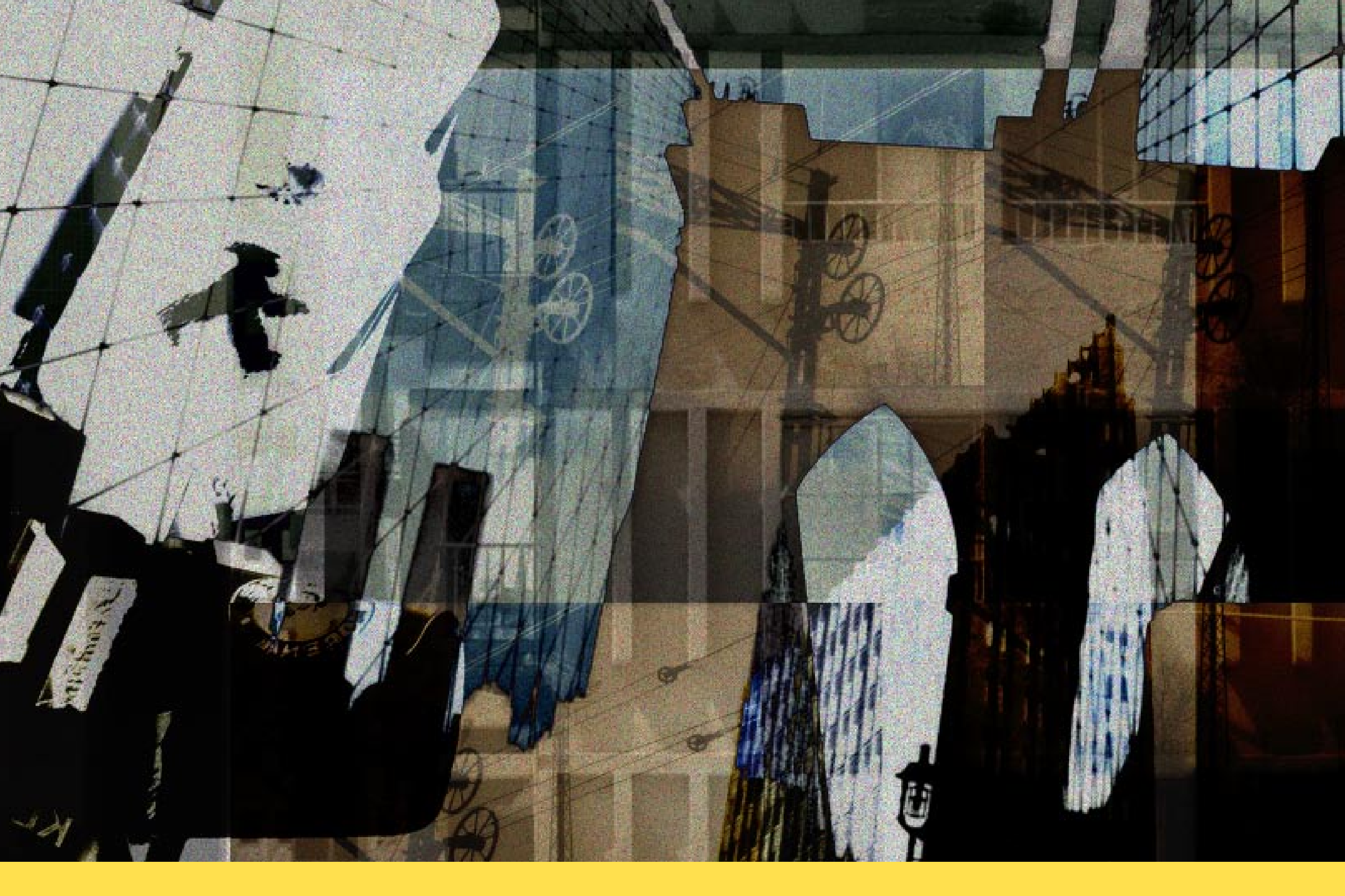


CONCHA JEREZ, JOSÉ IGES
***Terre di Nessuno: Quicksand***, 2002-2009

Truth is the least certain of things. It has reached the point where it is nothing but an empty aspiration, lacking content. Instead, we talk about whether something seems plausible: about news that has created a flow of opinions, for instance. A judge seeks evidence of the truth, but everyday citizens who receive information only ask that it seem credible. They have lost much of the certainty that used to drive them to take actions, to do something in favor or against something or someone, based on certain evidence made public. Our work places the user before true news that seems false and false news that seems true. But that is only part of how our field of uncertainties is set up. The setting is produced by the display of a set of signs that led to disorientation, at least, if not outright distrust: quasi-verbal gestures, meaningless blabbering; flags that correspond only to an indeterminate place called *Terre di Nessuno* (no man's land) accompanied by impossible anthems, a remix of genuine anthems that still sound strange to the listener; instructions to the player that encourage a non-competitive attitude if not an openly disconcerting one; limiting the installation space with video scenes that overlap diverse physical spaces, suppressing the allusion to a real space of reference, but also provoking an ambiguous, calculated sensation of spatiality in the installation.
And all that accompanied by the selected Web pages and blogs that change from time to time,




added to the torrent of information the game offers us. The game is a way of randomly choosing information. We have converted the fierce territoriality of the original Parcheesi into a game of delocalized information. This way, the visitor is offered a mine field and submitted to a flow of data which, in spite of their sometimes contradictory and sarcastic flavour, do have something in common: the intention of leading one to doubt. This is, as we said, a setting for uncertainty. And that is a small step toward independent thinking.
**C.J. and J.I.**



AETHERBITS
(Mariela Cádiz, Kent Clelland, Denis Lelong)
***Social Synthesizer_Prototype***, 2008

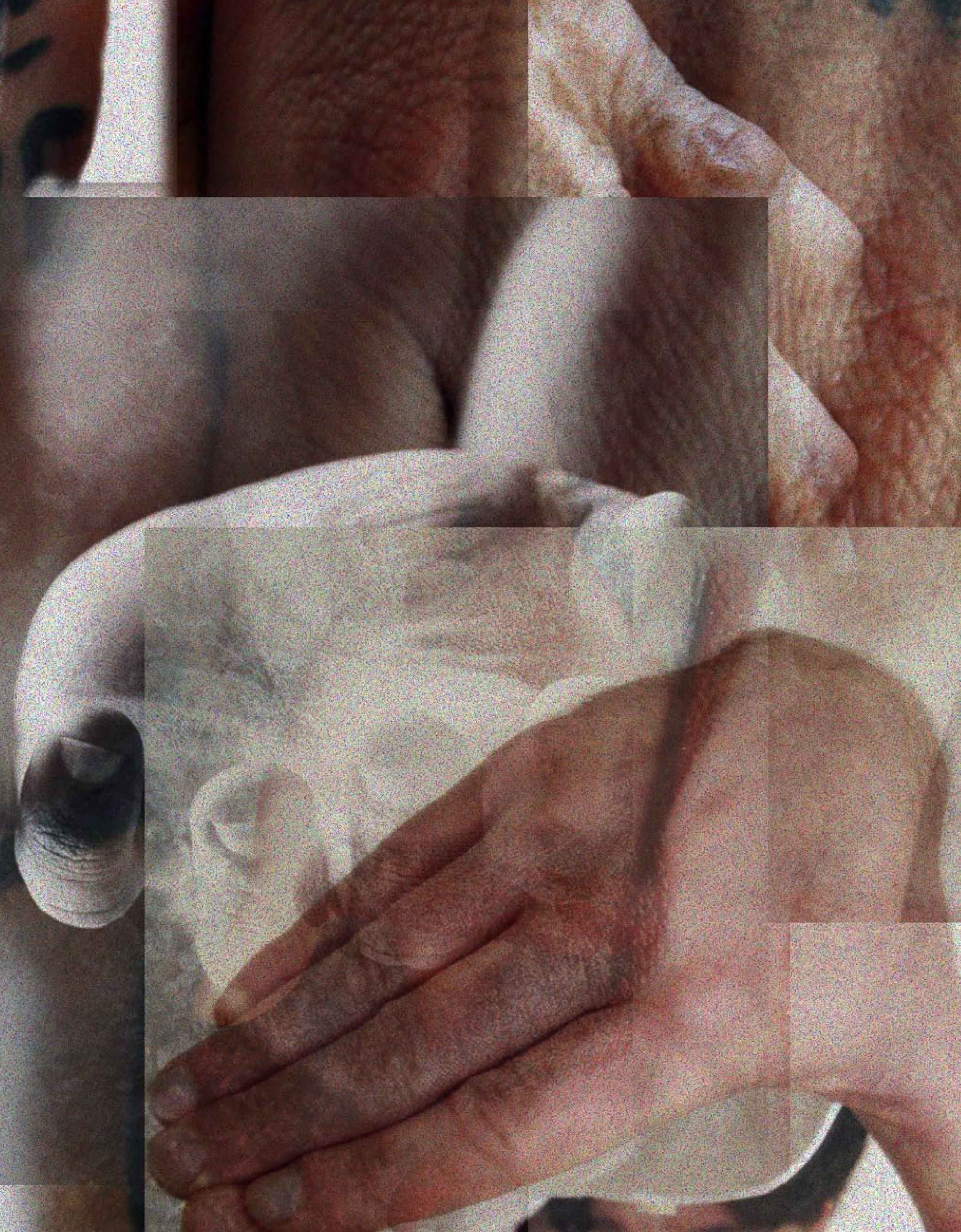
*Social Synthesizer* is the audiovisual synthesis technique pioneered by Aetherbits that explores the aesthetic synergies emerging from the contemporary use of collaborative internet technologies.
Presented as an on-line and onsite prototype, the *Social Synthesizer* uses datamining strategies to generate a perpetual realtime audiovisual composition. The result is a recombinant flux of sensory information aimed at holding a mirror to the collective unconscious as it emerges from the Internet in the form of social software and user contributed content websites.

The core of the *Social Synthesizer* is a real-time score generation application based on concepts ranging from Swarm-Intelligence (SI) to hash table mathematics and Database Theory. The Real-Time-Score-Generator is a technological mashup of custom-built software that leverages digital audio synthesis with polyphonic video synthesis techniques to power an immersive yet sublime environment capable of inducing higher states of information awareness. The Real-Time-Score-Generator simulates the patterns which emerge from the organization of data in databases. Like a virtual petri dish, it intimately links the technology of the on-line world with the biological concepts of our natural world. Data organization patterns become the score for an ever-growing self-organizing stream of collective art. One in which the entire



internet community can witness the evolution of, as well as participate in and influence. Its power is in its ability to convey information in multiple levels and dimensions: a specular lens into the world of on-line communities.
On-line, *Social Synthesizer _Prototype* uses a wide range of audio synthesis techniques on a database of user contributed recordings to algorithmically compose music. The community can influence the sound of the compositions by inserting sound recordings into the database. This is accomplished by using *Skype* (a software program that allows users to make free calls over the Internet) and calling to what is essentially a contemporary answering machine. The recordings become a part of an algorithmic computer generated stream of music that anybody can listen to and influence. Onsite, the *Social Synthesizer _Prototype* processes in real-time images drawn from *Flickr* (a website for users to share photographs). The archetypical images drawn from an user contributed content website such as *Flickr* become universal yet personal meaningful data that are reprocessed by an acoustically driven visual synthesizer.
The *Social Synthesizer _Prototype* is ultimately a sensitive content development system. It epitomizes the conjunction of creativity through diversity in an open media culture. Information as media, information as realtime collective art that, at the same time, is personally relevant and highly subjective. Social Synthesis.
**A.**

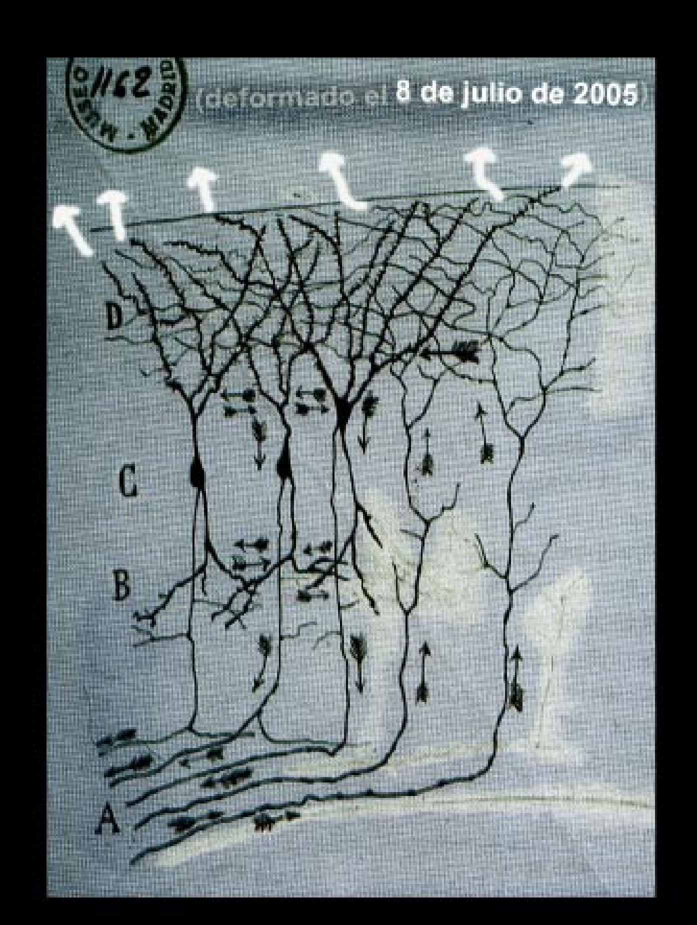


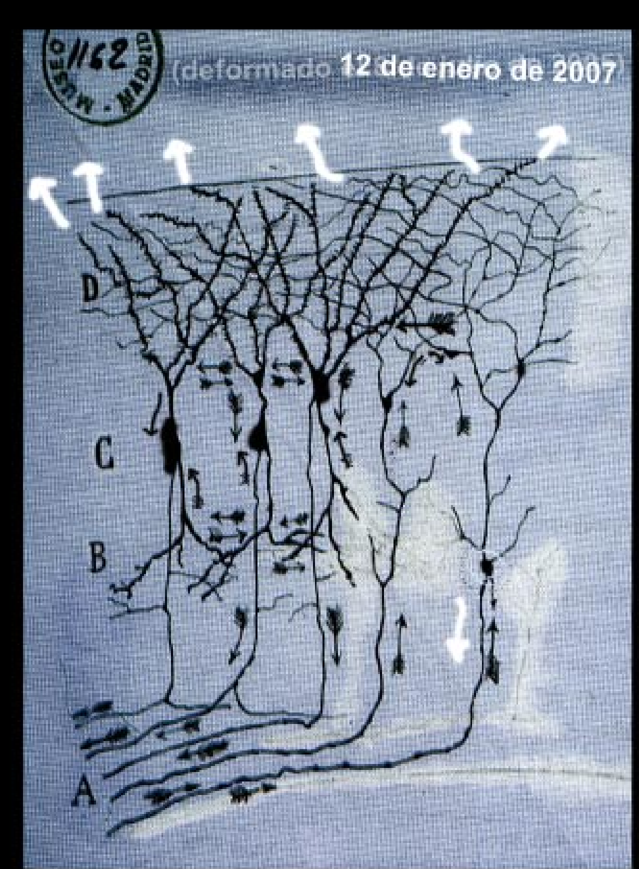




FRANCISCO RUIZ DE INFANTE
***Queen***, 2007

Visitors see before them an almost completely closed room. Its only access is a small 20cm opening. Located in this present but inaccessible space is "The Control Room". Along with a complex web of electric wire, the room contains a plug board providing energy for its proper functioning to ensure that the switch is always in the "on" position. Two prints of neural networks drawn by Ramón y Cajal are the only things visible on the walls. Some time ago, Deleuze coined the term "societies of control" to announce a technological future that would increasingly invade private spheres. To the extent that social logic and its surveillance systems have migrated from mechanistic parameters (closed, geometrical, analogue) to digital forms (open, in networks, delocalized), new forms of control have emerged that are more intensive, extensive and subtle: invisible. *Upgraded* versions of Bentham's Panopticon, which gains strength from the fact that they are located all over the place, throughout the "network society". For in effect, the "control room" is the network to its full extent. Thus, "watch and punish" is no longer necessary given that the Web — the possibility of being monitored on-line — is enough to generate the internalization of the norms of social equilibrium (socio-digital homeostasis).
*Queen* not only addresses the new parameter of control that is delocalized, fluid, flexible, possible, digital, in a network, and on the Web; it also points to an even more disturbing consequence:




the symbiosis of the biological and the technological in a techno-biological political network, sharing a sole dataflow between them. Based on the possibility that exocerebral networks (language, symbolic systems, the World Wide Web) constitute an essential part of human consciousness — the amplifying hardware and software it needs — a crucial new problem would arise. This deeply human but primarily social and political problem is that consciousness and power would reside in the same space (the no-place of the Web). This cohabitation between monitored subject and control technology in the same digital space could turn into something more than just a superstructure: the annihilation of resistance in logical terms. At the same time, and not without a certain subversive irony, *Queen* puts the finishing touch on the subject by enclosing, encapsulating, power in its panoptical room. Just as control technologies have been internalized given the virtual nature of constant control, the controller carrying out the surveillance cannot leave the control room. However, the room is empty.

**A.S.P.**



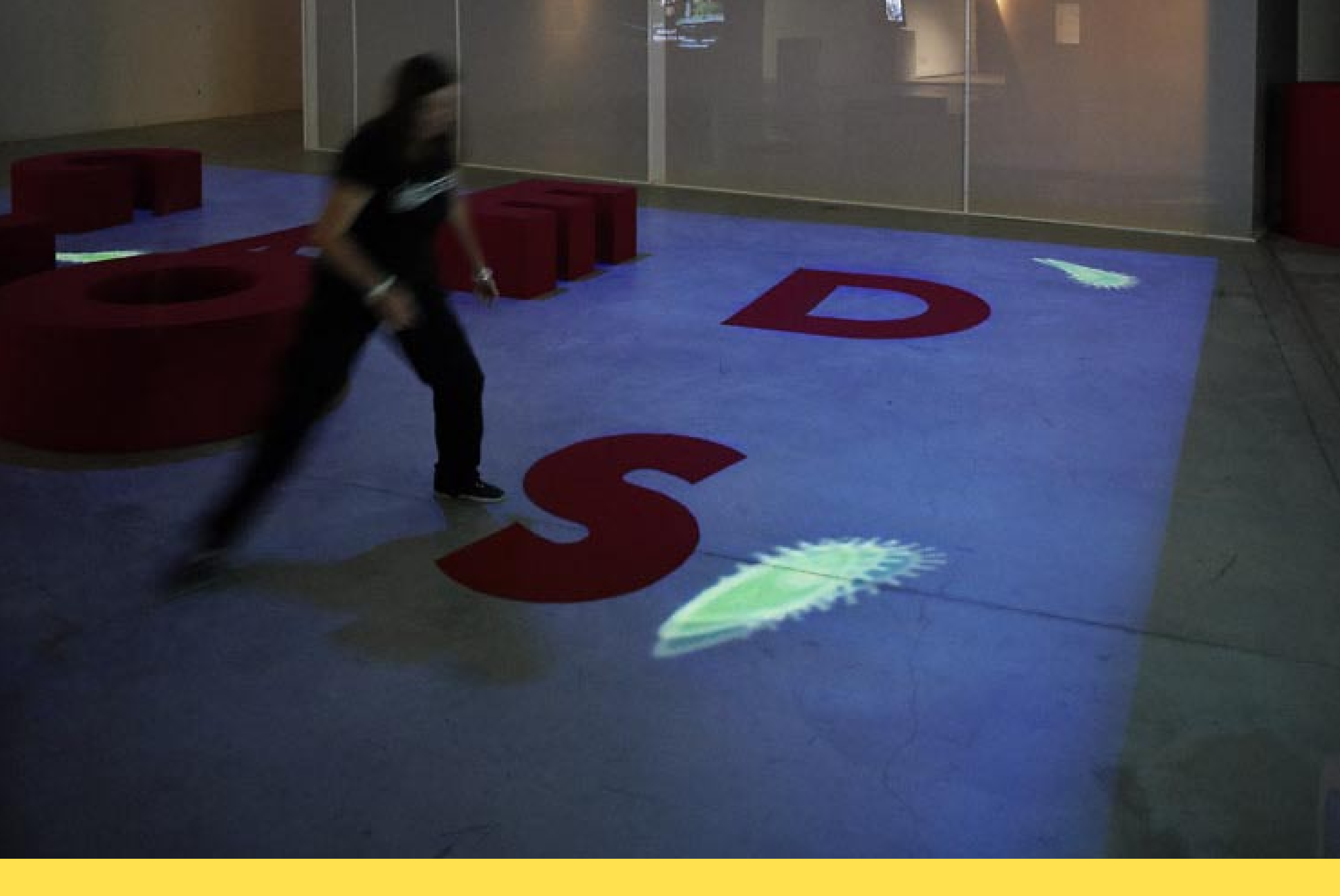





EUGENIO AMPUDIA
***Credulous***, 2009

One can establish an interactive relationship with a work in a variety of ways, but none can be more meaningful than that which emerges from self-awareness, that which signifies an actual change in self-perception. This is why the installation *Credulous* allows the possibility of interactivity reaching its most profound level. The visitor enters the space (only perhaps a true *place*), equipped with furniture and computer terminals, that apparently serves as an area to relax and connect to the Internet. Projected from above, giant amoebas cross the floor, flowing among and interacting with the users. An overhead camera simultaneously records and projects images of the room. Seeing the images shown in real time, the visitor not only discovers that the furniture spells out the word *crédulos* (credulous) but also sees him or herself immersed in a different scale of existence. Reduced to the microscopic level of amoebas and yet present at the same time in his or her own scale, as well as that of the telematic data networks.

This disorientation of perception is a first step in discovering that the microscopic level, human scale, and the global telematic dimension share the same organizational pattern: networks. The "fabric of life" thus appears as a multidimensional structure of living systems that are hosted inside each other successively. Organisms, populations, and ecosystems, level by level, form a collective of network system, a network of networks. The visitor, upon noticing his or her inclusion in this tapestry of networks contained within networks, will



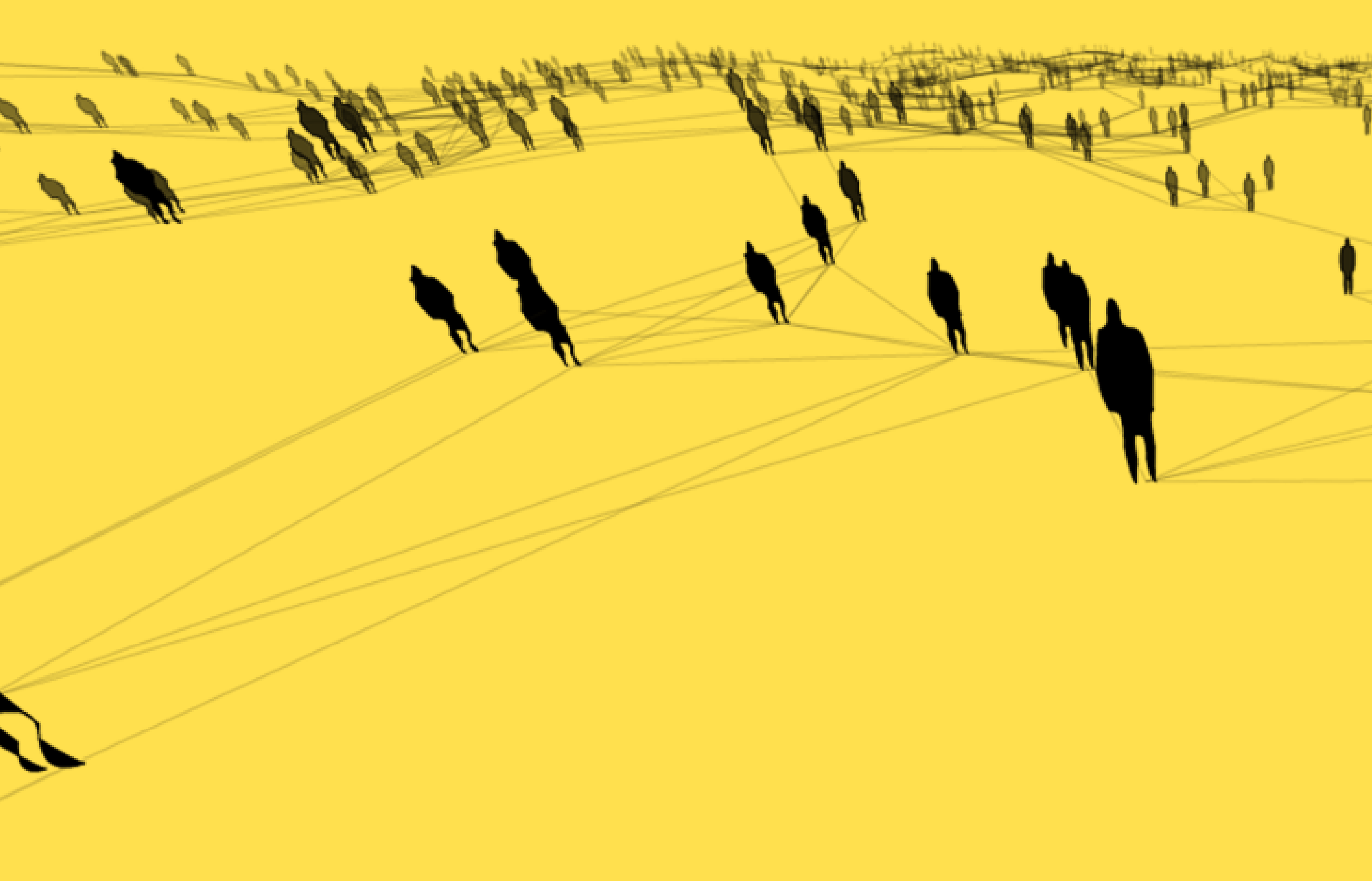
become aware of his or her locus. A relative, fluid, eminently relational locus, given that it exists at all the levels, from the macro to the micro. This new perspective modifies one's perception of the level of the social stratum where one lives. The experience of *Credulous* is thus perfectly incorporated into the dynamics of social autopoiesis. The registering of any level of existence in a single *continuum*, under a sole organizational pattern, upsets, displaces, and attacks the mechanistic Newtonian/Cartesian notions and legacy that, with their impermeable categories, may have explained life up to now. However, *Credulous*, with its meta-perspective proposal, offers an expanded opportunity to locate oneself in and move among levels, even at the expense of the mental destabilization caused by replacing inherited analytical structures. Recognizing this global, relational and fluid organizational coherence of which we are simply nodes at one level among many shows how credulous we are to think that life can be seen from a sole compartmentalized, closed and defined perspective.

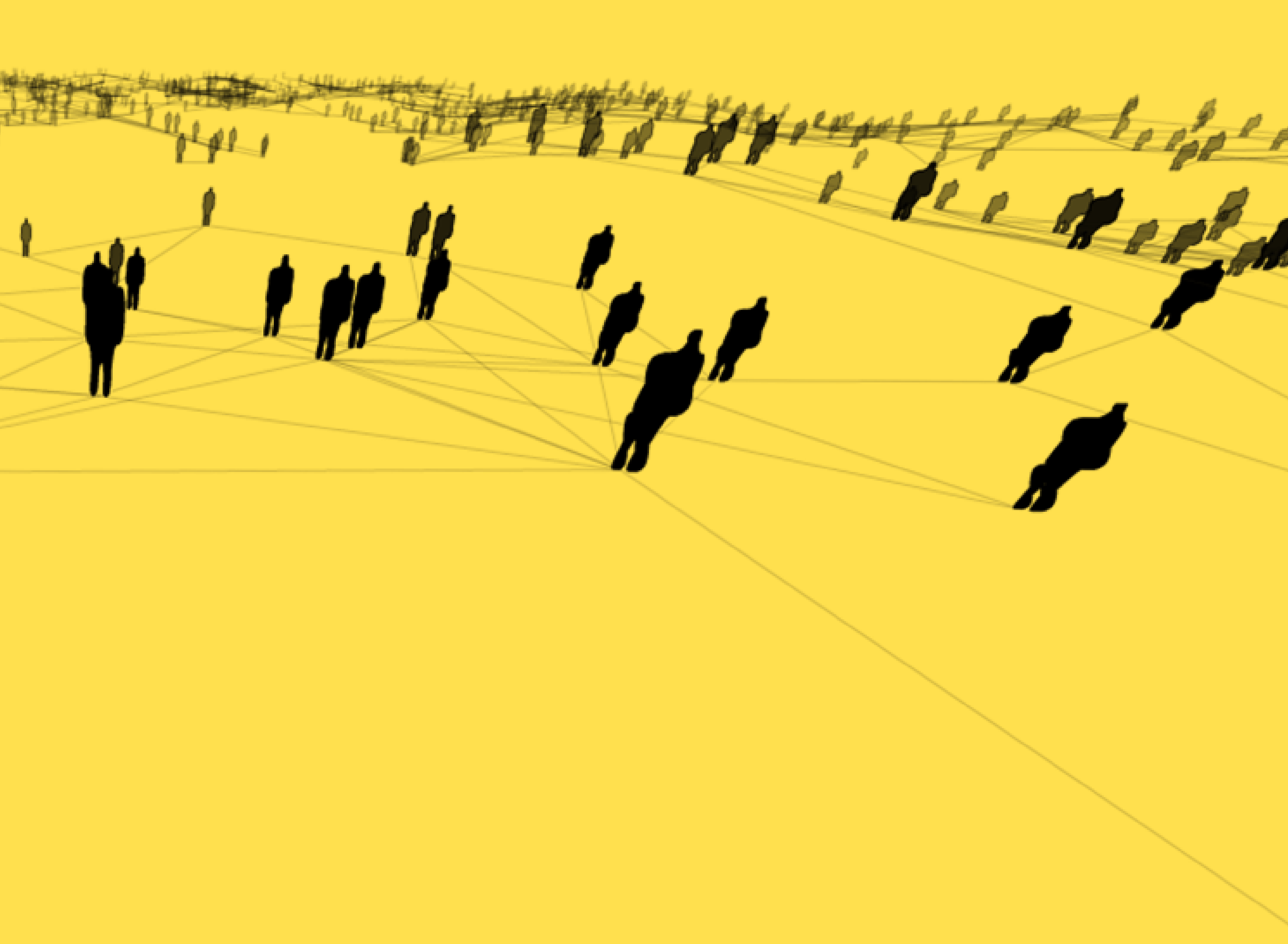
**A.S.P.**

***The concept of "network society" shifts the emphasis to organizational transformation and the appearance of a globally independent social structure with its processes of domination and counter-domination. It also helps us to define the terms of***

***our world's fundamental dilemma: the domination of programmes belonging to a global power network or, instead, the common emergence of the use value of sharing.***

**Manuel Castells**





## Networks: forms of symbolic and social construction

SANTIAGO ERASO, JORGE LUIS MARZO,
ARTURO RODRÍGUEZ, NATXO RODRÍGUEZ
5 June 2008,
21:35 h.
Nodes. Networks

### Presentation

Some of the vibrations many of us have captured in recent times when considering certain experiences linked to the idea of "network", especially since its digital spread, have again brought us face to face with the question: how is a political life (collectively) constructed? In the face of this question, cultural production, which is our sector, becomes a setting for friction between independent proposals and institutional or administrative structures. Cultural politics can barely be told apart from the global market and on all but a very few occasions the system of relations taking place in art and culture impedes any real effect on society. What capacity do the practice of collective creation, social and cultural networks have to produce changes in this situation? To what degree is the "network" idea inflated in the world of artistic production as well? Is the complex identification between network and internet and between community and technology useful and desirable? How can we avoid technological determinism? In its present form, is the web capable of constructing radically divergent experiences in the social realm?

### Functioning

This blog worked from June to October 2008. The entries were brief posts that worked like reports, quotes, detailed links and references to projects, texts and ideas, provoking comments by the forum's other participants. Anyone who wanted to add comments could do so, although the blog had a system for moderating those comments in order to optimize the final results and insure their agility (comments can be seen at <http://www.banquete.org>).

For all this, an agenda of subjects was set up and managed by the working group for the duration of this experience. Those subjects included connections between autonomous work processes, collective and decentralized creation, structures of notes and networks in the production and spreading of knowledge, and networks: "myths and misdemeanours", among others. The commentaries can be consulted at http://www.banquete.org/banquete08/-blog-.

1 Translator's note: The Spanish word "red" plays a key role throughout the texts or posts in this blog. Depending on its use, it can refer to the Internet ("la red" = "the web"), to a network of any sort, whether digital or not, and even, in one of Arturo (Fito) Rodríguez's posts, to a safety net of the sort trapeze artists use. Sometimes, it is used to refer to more than one of these things at the same time. At others, it appears several times in the same sentence or paragraph with different meanings each time. In this translation, we have sought to retain the primary meaning in each case, and the secondary meanings wherever possible.

## Espai en blanc

SANTIAGO ERASO
19 June 2008
16:47 h

In Barcelona, a city of large events and festivals, people act and react against the growing individuality of the experience. While there is a powerful tendency to fragment the city, communities are created and organize themselves as social networks, guided by the need to act collectively. In the face of the tendency to privatize knowledge, a "we" arises to claim a right to unmediated words and actions.
On 29 May 2008, Espai en Blanc organized the final meeting of the cycle, *Therapeutic Society.* Beginning in January, more than a hundred people had been meeting every Thursday at the Horiginal Bar to draw up a new politicization of thought beyond recognized maps of

the production of knowledge and of cultural institutions. In these meetings of anonymous voices without experts, arbiters or invited guests, we "thought together" through a collective process of "taking the word" to break the silence of de-politicization. On the basis of this awareness of collective participation, Espai en Blanc has also carried out other projects in which criticism can not only be enunciated, but can also push for a transforming education: *Congress on the War-State, 2002*; the publication of *Barcelona 2004 Report: Postmodern Fascism;* the magazine *Espai en Blanc (Materiales para la Subversión de la Vida);* collaboration on the film, *El taxista full* or the long process of research on *Autonomous Struggles in the Spanish State 1970-1977* and a book of the same title (*Las luchas autonomas en el Estado Español 1970-1977)*, published by Traficantes de Sueños. This was definitively, a sum of experiences calling for the individual "other" and the cultural "other" as protagonists of life in the triumphalist aftermath of the Grand Barcelona and the retreat of social movements. As Marina Garcés put it, "together, we have opened a world. The sum of you and me is not two. It is a 'between' where anyone can appear."

These may seem like two obvious remarks...

JORGE LUIS MARZO
24 June 2008
0:12 h

The following two remarks may seem as obvious as two bowlegged elephants, but they have to be our starting point when speaking of networks.
The first is that tools are not the same thing as goals. Naturally, they affect each other, but they are essentially different. Internet can create networks through its merely technical characteristics, just as a group or community of persons can generate specific technologies or transform existing ones in order to provide themselves with tools. But the meanings of the two terms continue to be different. Just as we speak of Galileo thanks to the "telescope"—technology – often forgetting that the latter was developed by science, so, most of the current discourses and narratives continue to assign a "foundational character" to technology in the creation and development of social activities.
The second, which derives partially from the first, is that speaking of networks does not necessarily mean speaking of Internet. The enormous spread of "digital networks" has blurred the notion of "community" so things will have to be clearly defined.
Any reflection about a "network" should be defined by what its members want to achieve with it. In that sense, I believe we need to distinguish between "reference" networks and networks with "goals." In drawing this distinction, I have no desire to set criteria of quality, efficiency or goodness for different types of networks, but I believe that the dynamics that distinguish them are evident and necessary when observing the phenomenon.
If the people who make up a network do not share clear goals, then we could consider the latter a "soft" network of the sort usually intended to collect registers, accessible files on experiences, attitudes and references (words and images). That would be the approach of new phenomena such as Youtube, Myspace, Flickr, Facebook and so on. Those sites—irregardless of whether they have become large companies or not—tend to define themselves as "spaces to share":

> Facebook is a social utility that connects people with friends and others who work, study and live around them. People use Facebook to keep up with friends.
>
> YouTube hosts user-generated videos and includes network and professional content.
>
> MySpace is an international site that offers email, a forum, communities, videos and weblog space.

> Flickr is almost certainly the best on-line photo management and sharing application in the world. Show off your favorite photos and videos to the world.

The fundamental offering of most of those digital spaces (*sharing websites*) is the capacity to publicly view users' contents that would otherwise remain private: videos, photos, audio and news. Those spaces "offer" the possibility to create communities. But communities have always been defined in a rather different way. What has changed?
In 2000, Langdon Winner said:

> The idea of a "constructive community" in the sense of "belonging" or "duty" places demands on its members that are sometimes very hard. You know you are in a community when the telephone rings and you are told that it is your turn to take on a task, working for months on a project the group considers necessary; organizing a fund-raiser, for example. Unfortunately, much of what has been written about on-line relations completely ignores the obligations, responsibilities, limits and mountains of work involved in true communities.

## Numb terms

ARTURO (FITO) RODRÍGUEZ
30 June 2008
22:02 h

Some concepts are suddenly inflated or deflated by the chronicles of our time. These chronicles are often written with the urgency of someone who wants to make history and is generally in a hurry to indicate how we will live in the future, or what new forms of social relations await us. Among all such ideas, "network" is being used to describe our society's current circumstances, placing us in a future we all experience in real time, even if we didn't know it (the scenario was already prepared).
It has also been used to explain the economy, terrorism and the world of media. Everything is a network and everything will be a network. Maybe this sort of obsession or inflation of the idea of a "network" is the easiest way of eliminating the complexity of the sociological framework in which we are floating without managing to find the tools that explain it. Or perhaps that is the easiest way to reveal the cruel simplicity exhibited by power at the present time. If, as we know, making this panorama visible, mapping it and offering it up, perfectly packaged, does not exactly imply a posture of resistance or opposition, then we would have to wonder to what degree the use of the "network" idea as a representation of modern society might not be a way of "switching off" analysis and criticism, of jamming rebel frequencies (the scenario has already been set and it is impossible to dismantle it because it is too large to grasp in its entirety...).
Could it be that we need to act on the different layers of that map, revealing the images that are covered by other images, unveiling the connections that are not in plain sight? Could it be that the all-encompassing idea of the "network" might wind up becoming totalitarian in the forms of work it offers us, in the information it supplies us and in the relations it proposes to us? (The scenario doubles, becoming an "alternative" scenario, but it does not manage to have any bearing on the "network" idea as it has no capacity for transformation.)
No matter what, the network has become a playing field for banking and clients, for government and corruption, for big fish and little fish, clown fish and flying fish. All of them will be caught in the net. We have also seen how other suddenly inflated or deflated concepts such as "post-capitalism" or "democracy" have become intertwined with the idea of the "network" to make a unified magma in which "everything" is explained, because there is a huge market that needs urgent explanations.

R. Dahl said that "democracy does not imply a large degree of participation by individuals, it implies that the poor and those who have not had access to education exclude themselves because of their political passivity." Just as all of us have understood that it is useless to seek "freedom" through a disorganized idea of "democracy", so, too, we should deduce that even if it were alternative and divergent, universal connectivity could not resolve emancipative concerns all by itself. The quest for new meanings of "liberation" and "connectivity" thus becomes the new scenario.
Recovering the idea of "community" (blurred, as J. L. Marzo put it), making our goal the politicization of aspects of our everyday life such as malaise, vulnerability and "existential precariousness" (once again, Espai en Blanc: see "Therapeutic Society") and reinterpreting the idea of "network" with an awareness of the obsolescence of certain conceptions we have been using until now, conceptions that have left us irrefutable maps and immovable stages — these have become our new tasks.

## Network(ed) art

NATXO RODRÍGUEZ
7 July 2008
19:07 h

Notwithstanding the fact that the ways of organizing our society are almost all perceived as eminently hierarchical and vertical, on many occasions it is actually a question of visibility. "There are an entire series of small microbial operations in everyday settings that propose the modification of technocratic structures and their manner of functioning."[1] It is hard for such operations to have much of an effect, but they are growing exponentially and are on their way to becoming the quintessential contra-hegemonic model in the digital context. The web's possibilities as a form of organization — networks of self-generating networks with unlimited connective capacities — are not reflected in the structures of art either, except for a few rather marginal experiences. Paradigmatic fundaments of the art system — ideas such as "heritage", "collection" and so on — that affect how artistic production is made, shown and even stored and conserved, do not correspond to an innovative notion of "networks" at all.
We have moved from vertical, hierarchical and unidirectional schemes for managing the art experience at all levels to a scenario in which networks constitute a new option as a basis for organization and as a new model for distribution in which relations occur in a more horizontal way between peers. This flexibility in relations can create a space for reciprocity in production, distribution and access, but it is not reflected as such in current official art production. The art experience continues to be organized and spread according to models that should be questioned and that continue to rest on the materiality of the artwork, the central role of the artist, the singular and original work, and the restrictive management of rights.

1 Arturo (Fito) Rodríguez: *Inquietudes, voluntades, afectos. Estructuras, redes, colectivos. Un segmento conector.* Fundación Rodríguez/H. Associació per a les Arts Contemporànies, 2007.

## A citizens' network after 11m

SANTIAGO ERASO
15 July 2008
10:18 h

Jorge Luis Marzo correctly differentiates between the soft network. in which connectivity is very high but the capacity for community construction or political discourse is low, and other networks in which commitment is constituted specifically as the sum of persons interested and willing to modify

reality. In these cases, technology is not an end unto itself, but a means to exponentially improve relational capacities and maximize communication among interested parties. Its use is subsidiary, secondary with respect to the network's constructive will. Certain networks can contain millions of nodes and be inoperative. Fortunately, though paradoxically, the capacity for action by a numerically "insignificant" group can be very large. On 15 December 2004, Pilar Manjón read a speech before the Congress of Deputies' commission investigating the 11 March bombings. That speech fundamentally changed the meaning of all the events that had occurred until that moment following the terrorist attack in Madrid. Society and the political class's perception of those events was altered after hearing the forceful words contained in that document, read on the basis of personal emotion and collective political rage. Several years have now passed and we still do not know who wrote that speech. The social and political dimension of the experience made it possible to found an unprecedented space: the *Citizens' Network After 11M.* The words of that speech were collectively interwoven in a participatory dynamic that overflowed all formal frameworks; it was done through the exchange of e-mails, documents written by each person, that were discussed out loud, in person, bringing new meaning to the physical importance of presence along with thought and writing, which could be virtual. It was a process both intimate and open, neither public nor private, where personal emotions could be shared in a network. It was also a successful process of speaking out, once again from the "between" for struggling together and in common.

*Desdedentro* ("from within"), is the collective name assumed by the group that published the book *Red Ciudadana tras el 11M (cuando el sufrimiento no impide pensar ni actuar)* ("Citizens' Network after 11M (when suffering does not impede thought or action)"). One of its members, Margarita Padilla, adds that the Network was a horizontal space in which there were neither categories nor hierarchies and all the members were on the same plane; a space open to social aspects that functioned as a network, facilitating flexible participation and commitment and offering each person the possibility to connect and disconnect according to their needs and circumstances. That informal relational structure allowed many people to feel they were participating in the drawing up of the text and that their voices could be heard. Pilar Manjón's voice was that of all of them. Alain Badiou speaks out for the political, transforming character of every event as long as it has language. On that occasion, the network of affected citizens produced a unique and unrepeatable social experience that seemed, for a moment, to suspend our lives, forcing us to rethink our political commitment. It confirmed that at any time we can be affected by reality but can also affect it ourselves through uncommon connections.

Despite the fact that time has passed, wounds have healed and reality imposes its crushing normalcy, the Network keeps a link open that allows us to reactivate our memory so that the amnesiac present does not forget our capacity to act. That link is: foroexperiencias@yahoo.es. It is a fine thread of communication and, as Eva Aguinagade — psychologist and active witness to the entire process — wrote: "I have left, even though I continue to be here. If the Network turns into a dispersed network of people who know they can count on each other, then that is fine, because what we have experienced is good and was important. I do not regret that the Network has become what it is now, nor does it seem sad to me. It is fine this way." The authors of the book add: "It is not strange that the experience of the Network is no longer active. What is strange and miraculous, is that it ever existed. And the miracle does not disappear, even if the Network does, because its existence has shown us possibilities we did not know about before. We know that what previously seemed impossible is possible, and by proving that something can exist, we have changed reality."



Santiago Ortiz, Cover for the book *Red Ciudadana tras el 11-M. Cuando el sufrimiento no impide pensar ni actuar*, Ed.Acuarela & Antonio Machado, 2008.

## Production lines without alienation

JORGE LUIS MARZO
24 July 2008
11:00 h

Recently, a Mexican friend who draws comics and has worked for U.S. comic companies such as Marvel and D.C., told me an interesting story. We should clarify that many *moneros*, as those who draw comics are called in Mexico, find piecework as a result of outsourcing by U.S. publishers. They work as labourers in the different stages of comic production, a type of work that is increasingly in demand thanks to lower salaries in Mexico, the high level of Mexican creativity and also the fluidity of Internet.
The story goes like this: the publisher sends the Mexican *monero* a sketched-out story based on rapid pencil drawings along with a list of specifications that define the general esthetic guidelines. Once the sketches reach his hands, the *monero* has to go over them with ink, adding more precise details. Obviously, those details are often lacking in the original, or they can even change some aspects of the original. Once this first stage is completed, the document is sent to a second *monero,* who adds the colour. This, too, follows guidelines set out by the publisher, but the colourist's personal style always has an important influence on the final results. The importance of the colourist's quality and personality is demonstrated by the fact that almost all of them appear as co-authors on the cover of the comics, and many become prestigious names. Finally, and always with the vigilant approval of the publisher, the comic is sent to a third *monero* who adds the texts, leaving everything ready to be printed. Now the most surprising thing is that the author of the comic my friend was talking about was Frank Miller. Miller is not just a well-known adolescent, he is a media star who made a name for himself in the movies. Finally, my friend said something like: "On the contrary, here in Mexico, our maximum pride is for one person to work on an entire album, without anybody's help, spending a huge amount of time and losing a bundle of money." We could add that there is something wrong here: continuing to consider a production line as something negative, even when it is not applied in a vertical way, but horizontally, when it is not radial but nodal.
In Spain, too, the notion of "artistic production" is defined by an artist's obsession to control all processes involved in the making of an art product. Given that the artist's specific style is his most notable identity trait, the entire process of creative production must be subject to the dictates of that style. The concepts of "collaboration", "shared or collective production" or "horizontal network" seem to have practically no place in that process. They would seem to imply losing the only thing that allows an artist to triumph: his mark.
Individual contributions in a multipolar network must be redefined in the context of a new technological and social reality. This structure can learn from past phenomena, placing them in a current perspective: stripped of its original reasons for alienation, the production line can become a very powerful constructive model. And an individual subject to the powerful pressure of isolation can find good reasons to want to participate in collective "dreams" that do not affect his sacred independence but can serve to bring

new value to different approaches to participation and interaction beyond merely pushing buttons.

This revision of the "assembly line" concept must, of course, include a redefinition of the concept of division of labour. While the discourse of its creator, Henry Ford, relegated workers to alienation because they did not have a complete sense of the product they were helping to make; in a horizontal situation of free association, each worker along the line appears not as someone subject to norms, but rather as a producer associated with that norm, someone who actively participates in it regardless of whether he originally created it or not. There is a division of labour in every collective as a function of available time, technical knowledge and skill, however the relations between various stages of an activity or project are less and less marked by the sum of individual times and spaces that do not correspond to the traditional image of an absolutely defined and closed group. That is where the notion of a "network" appears.

As sets of elements organized in neither vertical nor radial fashion, networks are defined by their decentralized character. In such a scheme, nodes or points of contact are spread around space without our being able to establish origins and edges. In reality, the work "network" itself has been so successful in recent years because of Internet, a delocalized and multi-node system. Somehow, the network questions a well-established stereotype when criticizing specific collective models: that there is nothing worse then living someone else's dream. A common critique of art groups is that, in them, personal options are blurred in the name of a general purpose. That has been one of the most widespread ideas in the narration of Spanish art, sustaining the importance of individualism as a form of creation and transmission. In the notion of the web, however, the individualistic character of personal participation does not disappear, it adopts new forms that can be very useful. As we can see in current models such as groups involved with "copyleft", free software, open code, or the broader framework called "club culture", on the web, individual experiences and knowledge are used to develop certain frameworks for work and reflection without imposing a final norm that would annul peculiarities and specificities. That working dynamic – a decentralized and voluntary production line – seems more like a support group than a traditional collective and is often aimed at the joint construction of shared learning and training activities. Thus, a network is made up of members who each develop their own personal work but are available to the other members to solve specific problems or encourage development in specific areas.

In this new relational framework, innovation and research receive new attention. Innovation consists of the set of trials and errors that emerge from the experience of combining personal knowledge, work experience, contexts (workplaces, for example) and professional experiments in a field where subjectivity is not a burden but an advantage. We are talking about a network in which the centers are made up of each of the nodes, not by any central one, although logically, some elements will be more dynamic than others. These are not a writer's fragile daydreams; in the cases mentioned above, we can see how such networks have reached authentic levels of critical mass and been able to directly intervene in our social and productive fabric.

## Network and everything that goes with it...1

ARTURO (FITO) RODRÍGUEZ
28 July 2008
11:50 h

We have referred to the progressive inflation of the "network" idea in almost all the texts and commentaries posted on this blog, and that should be enough for us to definitively ask how much this inflation really affects our creative projects, on one hand, and our lives, on the other, if in fact those

two poles are even separable. The influence of the "network" idea on an artistic project was blocked at first by the need to deal with a certain creative anxiety arising from the fascination of new technological possibilities. In the 1990s, this led us to forget some aspects of collective work until we gave political meaning to the network. In a certain way, this anxiety linked to the latest advances and newest versions, the "cutting edge", also separated us from the street. Quite a bit of time had to pass before we understood that technological determinism in the visual arts is in connivance with the "market boom" and that all this was nothing but a mechanism to deter or anaesthetize activism, which retreated to its customary haunts: communities. The web has those effects, communities are formed by shared interests, there is no access to what the others say, to otherness, where the battle is also being fought...

This situation (and I am still referring to the 1990s) led us to see cultural production in a new light, it all happened while the structures of cultural politics we had been dealing with were still adapting to new administrative mechanisms, that is, when culture's administrative bureaucracy was entering the tunnel it is still in. It has never left that tunnel to get a sense of everyday life. The idea of "production" we had after trying new technologies was no longer that of formalist, museum-worthy object-based art that was still the center of attention for institutions, and this break further widened the gap through which the ideals of a liberating project were draining away. We have been told that that project was once called the *avant garde.*

Nowadays, "producing" is also communicating. In other words, the term "production" describes processes of communication capable of generating action beyond opinion. When that production is the production of thought – the *idea* of the web even more than the web itself – it is a phenomenon capable of combining ideas, distribution and the spreading of knowledge. We could see this in the determinant presence of the "blog universe" and in the transmission of news outside official versions, and so on, as well as in many of the culturally divergent or anti-system initiatives we have known. And also in all sorts of actions and experiences arising from the creation of new communications spaces (web-radios, telestreets, the expanded idea of "broadcasting" that some of us have tried to develop, and so on). We experienced this with the Iraq war, with the problem of living space ("*V de Vivienda*"), with the progressive fall of political taboos such as the monarchy (how can we talk about the web when a spider web covers the ridiculous crown?). But when the product reaches beyond the mere spread of ideas, when it needs logistical support in order to reach a specific audience in audio-visual formats or publications, we see how distributors belonging to large media cartels work with an inaccessible and unbridgeable network. In that sense, the experience of producing and distributing alternative cultural materials becomes the true cutting edge, the true *avant garde*. These are networks calling for complex nodes, also called "economic resources".

If, as we said, the image of the network in the broadest sense appears to be subject to overnhelming numbness – suggesting infection or illness – then we may conclude that we need to seek out different levels of connection inside it. Levels of connection not limited to the marketing of ideas, that work as a device capable of moving the pressure point to the right place in each case. It is a matter of rethinking our strategy and tactics, or at least continuing to think about them and about how to recover the meaning and efficiency of a network for our project... As Eduardo Subirats said recently in an interview published in the cultural supplement, *Mugalari* (from the newspaper, *Gara*), "the dissolving of the modern project is converging with a new electronic totalitarianism." In the light of this situation, he again points out the need to offer alternative approaches, the role of the committed intellectual, col-

lective reflection and so on. But as always, things seem to remain on the level of theoretical criticism, awareness and reflection. So the same old questions continue to beat on the web's door: Where should we really act? Where is the crack in the system that will allow all of us to sneak in with our arsenal of reflections ready to be definitively applied? This is criticism of the criticism that appears in the loop produced by the web when it becomes entangled in its own definitions...

I will leave the other aspect I mentioned at the beginning — how this inflation of the "network" idea also influences our lives — for another post. Suffice it to say that it seems strange to me to speak about a network at this banquet, with all the resonance that term carries, when I have the sensation that I cannot share this meal with more people; I would not want this to seem like an exclusive feast.

There is one final question that I do not want to overlook here. Much has been said in this blog about types of networks and in that sense I would like to bring up a text I consider essential. We had the good fortune to be able to publish it in the catalogue of QUAM 07, directed by the Rodríguez Foundation. That text is "Ecosistema red: nodos que convergen y organismos vivos" ("Web Ecosystem: nodes that converge and living organisms") by Tere Badia, and it comes from the lecture she gave at Montesquiu Castle during QUAM 07 on 8 July 2007. It can be found at http://www.h-aac.net/.

Web tools, 1

NATXO RODRÍGUEZ
6 August 2008
11:36 h

There has already been discussion here of the greatest hits of new web culture (Myspace, Youtube, Facebook and so on) that urgently call for critical analysis of this tendency to use the "network" idea as a solution for every problem. That questioning also needs to be directed at the field of tools, where some of the myths discussed in this blog also crop up in the same way. This tendency often leads us to consider tools more important than goals when, in a new project, we start right off by putting together a "wiki", create a mailing list or start a blog, which might be the case of the space where we find ourselves right now. Somehow, divorced from the large "sharing spaces", these two-point-oh tools invite us to participate, interact and collaborate as if such activity depended on the chosen software's capacities rather than on the tissue of relations that a group or community is able to weave.

I wonder if this reality has to do with an obsession that I, myself, suffer to a certain extent: the effort to transfer the experience of free, open-code software (the quintessential web work, as Fito put it) to other fields of cultural production. Blinded, perhaps, by the success of free software as a sustainable project, and by copyleft as one of its consequences, these efforts to transfer their benefits are often made in such a literal manner that their application to fields as different as art make the gap practically unbridgeable. And yet, their efficiency is such that they continue to be models for us, and some of their characteristics are very useful for politically activating and tensing our networks. Some of these ideas can inspire us to consider other possible artistic practices such as those listed below:

• multitasking, simultaneity, multi-disciplinarity: a contemporary practice that facilitates the simultaneity of processes, sharing resources among agents, institutions and such that do not necessarily share a physical space and that overcome traditional interdisciplinary barriers beyond even the limits of artistic practice itself and the role of the artist as author;

• multiuser: from the announced death of the author in favour of the text and the reader, to the idea of "collective intelligence and creation", various conceptual frontiers that

limited the world of cultural production are now more questioned than ever before. Digital technology and its application to the Internet pave the way for a progressive dissolving of the concept of "authorship", as it has been understood until now;

• Display/interface versatility: there is a growing gap in the devices and equipment providing access to contemporary art. This gap arose in the 1970s with the emergence of new media such as video or television, but at that time the device constituted by museums and galleries was able to react, adapting to the demands of new displays and interfaces. Nowadays, for example, video art and audiovisual creation are flooded with recent advances in the field of on-line video, and these new models of production, distribution and access to certain works violently collide with galleries' and museums' reigning modes;

• The independence of devices: most of these new devices enjoy considerable autonomy with regard to the dominant vectors of the art system, especially as regards the market as a frame of reference;

• Open code: the notion of "open" underlying the idea of "open code" also extends to other fields, although its application to the field of art production is not at all straightforward because of differences in how software and artistic languages understand the term "code".

## Neither apocalyptic nor integrated

SANTIAGO ERASO
12 August 2008
10:26 h

Cultural criticism is older than its name. Plato's myth of the cave is its unequalled paradigm. The analysis of reality and its representation, the loss of meaning and its adequacy or inadequacy are recurrent questions that can be applied to the study of technological advances. Every time humanity develops a new tool of progress, there is a confrontation between supporters and detractors. Innovations in the field of communications have always been pursued by the ineluctable shadow of suspicion. Literacy was a threat to the privileges of scholars and the erudite. In the 18th century there were warnings against reading novels, which became commonplace on the threshold of the Enlightenment. Now, the same sort of criticism is directed at television as a mediator of "stupidity", or the Internet as a source of cognitive trash.
It took many years for norms to appear in the study of the relation between the media and communication. For centuries, it was an appendage of philosophy. In 1932, with Nazism on the rise, Bertolt Brecht announced it in *Theory of Radio*, a premonitory text about "the radio as a communications device". A year later, Goebbels created the Ministry for the Peoples' Education and Propaganda, for Hitler. Soon thereafter, in 1936, Walter Benjamin wrote his famous and frequently quoted text *The Work of Art in the Age of Mechanical Reproduction*, in which he announced changes in the field of communications and substantial modifications in the concept of the artwork. Since then, digital technology has carried those modifications to far greater extremes, especially noticeable in very frequent references to how the concept "original" has lost meaning. Despite this progress in the study of the relations between technological advances and communication, academia still barely considered it in the 1950s. It was thanks to Marshall McLuhan's theories about television in the 1960s that its importance and effects began to be recognized, leading to a popularization of concepts such as "Gutenberg galaxy", "global village", "cold" and "hot" media and "the medium is the message", as well as the description of "communications media" as an "extension" of people. There have been considerable advances in this sense in recent decades. Ever since knowledge

has become an industry, the science of communications and media has attained a growing presence in academia. Now it is common to hear about "culture industries". In fact, beyond this corporative conception of culture, it is difficult to find knowledge that has not somehow been integrated into the market. Any form of producing subjectivity, artistic manifestations or cultural activity can be converted into an "exchange good", relegating its "function of use". Definitively, "mass media" plays a central role in political agendas and economic interests. It is worth remembering the magnificent work Fito Rodríguez and Jorge Luis Marzo did in *Spots electorales (el espectáculo de la democracia)* ("Electoral TV spots (world selection since 1989)") to show how communication and politics have moved towards advertising over the years.

In 1965, Umberto Eco published *Apocalyptic and Integrated*, a study of popular culture and communications media that examines society's different postures in the face of mass culture. In a similar sense, in an article titled *The Digital Gospel*, German philosopher and poet Hans Magnus Enzensberger wrote:

> The fact that media prophets appear in double lines surprises us. Both factions follow a model known to the history of religions. On one hand, we find the apocalyptics; on the other, the evangelists. In more than one sense, technical progress has been presented as the successor to revealed religions. Salvation and condemnation, bliss and damnation.

The so-called "apocalyptics" see mass culture as "anticulture", that is, a sign of total decadence. They refuse to recognize any new progress as valuable because its acceptance would signify the total annihilation of established cultural patterns and the disappearance of canons. They condemn everything associated with new technology and its use in art; rejecting the distribution and democratization of information and knowledge.

In clear contrast, the "integrated" optimistically and blindly believe and defend this phenomenon. They are convinced of the goodness of new technologies and spread knowledge of them as a fundamental part of a freer and more promising future. As Natxo points out in his latest post/text, for the integrated, new web culture (Myspace, Youtube, Facebook and so on) is now being presented as the solution to all problems. The most ingenuous see the global village as a panacea for all ills: communications and the establishment of free worldwide networks; direct electronic democracy; equal access to knowledge; the disappearance of hierarchies, and innumerable "gifts" of digital democracy that will bring us a better, more harmonious world. Beyond enthusiasm, innocence and manicheistic duality, the reality being configured by digital technologies is a complex landscape that cannot easily be reduced to a simple confrontation between good and evil. We must not forget that the true gospel of the web is capital and therefore it is difficult to escape the contradictions this generates. Just as other communications media have succumbed to the seduction of business, the Internet has never ceased being a space that can be conquered by large industrial and media corporations. Efforts to put an end to the web's independence, beyond its subaltern relation to capital, are becoming increasingly difficult to avoid. The encroachment of advertising on knowledge, attacks by management companies in connivance with many governments to make P2P networks illegal, proposals to "regulate" and control contents — the definitive shutting down of its communicative potential — are all the rage.

In such circumstances, the only place we can develop paths to social criticism and reappropriation of the digital experience is in the gaps left by certain incompatibilities or disagreements: the antagonism between the culture of "ownership" and free culture, between copyright and copyleft, "owned" software and free software, between individual authorship and collective or collaborative creation, between the restrictive concept of "original" and the defence of copying and

appropriating, between the culture of scarcity and that of abundance, between what is "available" by permission and what is accessible, between academic science and social sciences or 2.0, between authoritarian education and participatory pedagogy, between centralized information and citizens' journalism, between cultural monopolies and independent productions, between criminalizing legislative efforts and antiauthoritarian flows, between the culture of panic or plane and that of freedom and shared responsibility. This antagonism can be resolved, as Natxo says, on the basis of concepts such as multitasking, simultaneity, multidisciplinarity, multiusers, display/interface versatility, the independence of devices and open code.

## Collectives and public policy

JORGE LUIS MARZO
18 August 2008
11:25 h

The reigning opinion has customarily been that unofficial collective commitments have always been produced through the pursuit of an objective of service to all members. Political, intellectual, religious, cultural, scientific, artistic and philanthropic associations functioned thanks to their capacity to define a clear objective whose pursuit would improve social surroundings. At the same time, somewhat different dynamics characterize sporting, commercial and technical associations and the like. Their objective is not so much social "commitment" as the generation of a shared framework in which to unfold and develop individual interests. Intellectuals have often disdained the approach of these non-cultural associations, comparing them to guilds or trade unions, as this approach is not especially pleasing to those whose mentality stems from the 20th century *avant garde*, where one is expected to make oneself.

Some years ago, Fito Rodríguez stated that the problem of authorship in fields like art is the amount of short-circuits it poses, especially when the political and economic weight associated with the notion of the "artwork" has been cultivated with such fervor. That is why the new reflections on the production line made by my Mexican friend are so important. The artwork must be separated from the concept of authorship and more emphasis placed on the need to create working environments in which new ways of conceiving artworks become possible. Moreover, I do not believe that we need to rid ourselves of the artwork: what I am emphasizing is the urgent need to consider collectivity as a format in which to foster new modes of production, distribution and sociality. There, new works will naturally be generated.
But in order to rethink the binding character of the artistic experience we must keep one clear fact in mind: cultural institutions, including many curators, detest plural creators, considering them production lines of the old, vertical sort that that they need to dominate and monitor in pursuit of the artwork and its artistic identity.
Art policy fears groups and collectives because it sees them as motivated by programmes that reach beyond mere aesthetic concerns. I know very few Spanish institutions willing to support either the production or promotion of activities carried out by collectives. And when they do, the results are almost always a failure. Failure is cited to cover up the difficulty institutions have in controlling and overseeing work. Groups are accused of being politicized or having an ideological bent, of lacking professional discipline and responsibility, which actually means that the institution is unable to free itself of the client-oriented network that dominates the infrastructures of the art world. While there may sometimes be some truth in these accusations, it is equally certain that the difficult relations between art institutions and creative groups arise because the former are not prepared to con-

sider an art policy that serves non-artistic agendas, given that their main focus is on attaining and obtaining defined, finished artworks.
As I see it, one of the greatest burdens to the professional and creative development of groups and collectives is institutional dependence. The importance of public subsidies for the development of activities is accompanied by a logical adaptation to the programs designed by those institutions. When an institution budgets for a subsidy, it automatically means that they are looking for the logic behind a project, after all, a subsidy is awarded for a project. That may seem logical, but it hides a dynamic paradox: it cannot lead to the creation of areas of reflection based on criteria that reach farther than the drawing up of specific projects. In that sense, I fail to understand the reticence of some collectives or groups to accept the idea of credit or shared financial responsibility. Curiously enough, this touchy debate is taking place right now among certain cultural institutions in Britain. The logic of risk that is implicit in the awarding of financial credit is often interpreted as something intrinsically opposed to the ethics of art, the argument being that the practice of art cannot and must not be linked to a profit motive. But from that perspective, profit is morally irreproachable as long as it is the result of an explicit will to do business, or even more intriguing, when an artist's career has become successful commercially, "thanks to his quality". If that is the case, then there is no problem.
Art practice's capacity to accept public subsidies but not to assume financial risks leads us to pose important questions. First of all, should an activity whose goal does not include the development of a commercial product always be linked to outside subsidies? Clearly, those activities whose outcome is a marketable project might find the idea of a loan more logical, but what happens when that is not the case? How can we free ourselves of the acute institutional tendency to co-opt those activities that promote non-profit activities as soon as they receive subsidies? Moreover, it cannot be denied that there is a certain tradition of parasite among many cultural agents. And when I say "parasites", I am not using that term in a disparaging way, but rather in the most "punk" way possible. The tradition of Romantic thought, updated a thousand times in different ways over the decades, states that the artist resembles a sort of "good-for-nothing" who can subtly transform the perception of reality in an unexpected way. Like the musician or artist who one day has a "hit and everybody shits themselves", in Sid Vicious's now classic description. That is the traditional notion of individualistic artistic practice that has so brutally contaminated many musical practices. But the dynamic created by a collective very often makes its objectives public and transparent in an inescapable way. I know of almost no creative collective or group that fails to define itself by some sort of programme, almost always with social connotations, to transform the contexts of genre, ideology, labour, sex, production, education or whatever. The mere willingness to implement social transformation should be directly associated with the real practicality of projected proposals. Like many earlier ones, current creative collectives are defined by their capacity to overcome traditional artistic endogamy, taking on social, cultural and political subjects that enormously broaden the conceptual terrain of groups dedicated exclusively to artistic questions. It is specifically this sociopolitical aspect of many collectives that generates mistrust in artistic and cultural institutions still dominated by formalist and self-referential creative discourses.
In that sense, the artistic context itself is a handicap for visualizing and developing collective proposals. Museums, galleries and institutional art programs are so channeled by their artistic expectations, so codified as places for artistic experience, that collective projects that propose readings that are

not directly esthetic have difficulty making a place for themselves there, even when they have been developed by artists. As a result, may such ollectives find themselves in the paradoxical position of having to develop their programs outside the art context in order to reach people without having to wear the label of "artwork". This often generates a great deal of frustration because artists do not know how those non-artistic sectors function, not to mention that both the public and the art world have difficulty grasping the attitude and stance of those collectives with any clarity.

## Network and everything that goes with it...2

ARTURO (FITO) RODRÍGUEZ
25 August 2008
9:14 h

I have waited until this second part to try to deal with the significance that the (overcrowded) term "network" or "web" has attained in my own life, having confirmed the impossibility of dissociating it from my creative project. And this is where the vertigo of thinking about oneself nowadays leaves us paralyzed at the edge of the cliff, and paradoxically without a safety net. Facing questions like this, which involve including ourselves in the landscape we are analyzing along with ideas that are nodes, networks, or traps—not to mention how slippery and even blurred the terminology is—is certainly a complicated task. How and where can we fit what is happening to us into these slippery territories of the "Cyberworld", "the politics of the worst?" And how and when will we find a place for our conscience and the like in these "Hypermodern Times?"[1] Do we still have to relate to the world? Wasn't that already taken care of? "I'm gonna *google* it!" is a colloquial expression used to settle all doubts.
After reading quite a few things in an effort to nourish a credible incredulity worthy of a presence in this text, I found nothing inspiring or sufficiently intense, so I return to Espai en Blanc's ineluctable publication *La sociedad terapéutica* ("Therapeutic Society"). Here, I am referring especially to Wenceslao Galán's text: "Nosotros, el psicoanálisis y la política" ("Ourselves, Psychoanalysis and Politics") which appeared before me like a mirror, or better yet, like a psychiatrist's couch to which I felt connected from the very beginning. It says what I would like to have said or at least it was exactly what I needed to read... I will quote a bit of it here in hopes that it leads you to read the whole text, which manages to set out the relations I hoped to cover in the present text: the difficult task of integrating our survival in the connected world from a political standpoint. W. Galán wrote:

> In short, we have passed from the regime of discipline to that of control, from that of distributed attributes to that of general mobilization. The effect of this shift is that reality is no longer presented as a conflict between the discourses that construct it, free it or argue over it. Our relation to the world, our way of "being there", no longer involves nor implies any decision, possibility or event, nor the moment that comprises the shape of the world or the meaning of a life. On the contrary, reality is no longer "the thing" we have to connect to. This, then, is our relation with the world: connect or die.

Just as power managed to turn fear into a weapon, inoculating us with self-control and making each of us the others' watchman, so, connecting has become a simile for "being here" and is well on its way to identification with simply "existing".
In his text, W. Galán develops the idea he calls "the transformation of signifiers" which have shifted from being links in a discourse to become nodes that connect it and us to "a flow of abstract possibilities". In that

sense, surviving is investing in one's own connectivity; success depends on the quality of your connection and power is established in the interest of the nodes contained in its discourse...
In that way, we see how an interiorized idea of connection — which is quite simply the idea that the web passes through us — reaches our awareness, becomes a part of our senses and affects our perception of our relations. We "exist and are present" in the same landscape that we frequently discuss and about which we write with a pretended distance. We cannot ignore that an interconnected world like ours demands new tools to interpret it and that these tools will probably have to be developed through forms of cooperation that have yet to be explored. Forms in which the collective undergoes a development that, while still "committed" (given how languid that term is becoming), will be able to "reconnect" with real scenarios for debate in which transformation becomes a real possibility.
In these circumstances, moving onward and upward towards the banquet table by the most complicated route, how can we find the gaps Santi mentioned in order to put the operations listed by Natxo into practice? How can we take on the collective work to which Jorge referred? How and where do we have to look in order to act together through the short circuit, through combined action in the areas of culture, art and communications in order to set social goals? And most of all, how are we supposed to belong to this movement? How are we supposed to be in this type of operation?

1 These two titles suddenly cropped up in the sentence almost by chance: following Virilio's *El cibermundo, la política de lo peor* (1997), we understand the need for resistance against the phantom of virtual democracy and we gup at the realization that, hidden behind internet was the militarization of information in to form of the "military-informational complex", as the author called it. In other words, a new form of totalitarianism... With Gilles Lipovetsky's *Los tiempos hipermodernos* (2006), we have understood precisely what postmodernity was — for the author, postmodernity actually ended with the triumph of consumerism, hyperindividualism and the workship of the present. The web is no longer an external element, there is no specific analysis of it. Instead, it is a vechicle and scenario for this neophilia. Forgive me this rather superficial comment, but in the almost ten years between one book and the other, I have perceive a sort of muting of the alarm. Virilio's text woke our criticism as if it had been served up with hot peppers; but with Lipovetsky, the criticism arrives on a large plate decorated with a jam made from the same peppers...

## Social internet. from monopolistic domination to social self-management

SANTIAGO ERASO
1 September 2008
11:59 h

Beyond Paul Virilio's apocalyptic positions in *The Cyberworld, The Politics of the Worst*— mentioned by Fito in his latest post — where he denounces how totalitarianism on the web reduces humanity to a sort of egalitarian but antidemocratic uniformity (what Eduardo Subirats called "new electronic totalitarianism" when referring to the latest attempt to put an end to the modern project), the truth is that the web's capacity to connect (us) is in danger, threatened by the same ideology that dominates it: capitalism. I do not believe that Virilio could escape digital fascism simply by excluding himself from the users' web. The practices of domination that affect the web are the same ones that asphyxiate our daily lives. Being in or out does not imply freeing oneself of the contradictions immanent in our everyday existence. It is also a matter of impeding the cancellation to which the web is subject — social networks in the broadest sense — and reinventing its political potential, just as we act against any other strategy that menaces daily life.
In recent weeks, various communications media have announced the application of means for

its control. From modifications in French laws to the latest accords signed at the G-8 meeting in Japan, everything seems to be directed towards annulling or hindering mechanisms that allow millions of people to cooperate with each other and contents to be freely distributed.
On the seventh of July, the European Parliament's Committee on the Internal Market and Consumer Protection voted to reform the European Law of Electronic Communications. Various amendments were proposed that seemed to threaten the future of one of the most widespread uses of the Internet. Those amendments encouraged reducing the quality of a connection when a telecommunications provider (ISP) detects that a user is carrying out non-commercial exchanges, and sending automatic warnings to dissuade customary users of P2P networks. For the time being, those amendments have not been approved but let us not be fooled, attacks on peer networks are part of a complex and contradictory strategy by different sectors involved in the industry of knowledge production and companies that manage authors' rights in connivance with some governments. A member of the collective *Conocimiento Pirata* ("Pirate Knowledge"), Guillermo Zapata, wrote in *Alternativas: control del conocimiento; de la resistencia a la ofensiva* ("Alternatives: Control of Knowledge; From Resistence to Taking the Offensive"): "it is not so much a matter of impeding the free flow of contents as of criminalizing it and imposing a logic of scarcity that allows its posterior exploitation. It is a matter of constructing a space between 'free culture' and '*proprietary* culture,' a culture of what is 'available' by permission, following payment, and ruled by increasingly strict regulations."
In this sense, one of the key questions for Internet's future is the decision that will soon be made about control of peer-to-peer file-sharing networks.
Who will legislate the future of P2P when Spain presides over the European Union? In the current Government, tensions between different sectors involved seem to be represented in two opposing ways embodied, in turn, by two different ministries. Not long ago, César Antonio Molina, minister of culture, said: "Attention must be focused mainly on the battle to prevent attacks on intellectual property in the digital domain." A few days later, the minister of industry, Miguel Sebastián, seemed to be distancing himself when he said: "we will not apply any restriction or regulation that impedes expansion or discourages the use of the Internet, nor will we set limits on the tools used for the free circulation of information." These two positions seem diametrically opposed to each other, obeying the conflicting interests of economic sectors involved in the resolution of this disagreement. Despite the possible differences however, the governmental discussion is limited not so much to a political decision to legislate in favour of a social Internet in the public weal — which is only right for a government that calls itself socialist — but rather to how to pragmatically insure the continuation of specific, more-or-less anachronistic businesses without hindering the emergence of others linked to the development of new technologies. In other words: how to agree on a legal framework that guarantees the future of web business rather than regulating or favoring its access, given its social value. Thus, it is a matter of somehow subordinating Internet to the interests of economic profit, thereby annulling its political potential.

## The museum as hub (web tools, 2)

NATXO RODRÍGUEZ
8 September 2008
18:18 h

Following some earlier comments (Pedro) in this same blog, I will return to the idea of museums and networks here. Thinking about museums and the future at the same time may

seem like a contradiction in terms nowadays, but some of us cannot stop thinking about updating the traditional hegemonic structure of the art system. That update never seems to arrive, but we continue to be optimistic about the idea that it should be out there, just around the corner. And sometimes, at least as a matter of intention, it seems to appear fleetingly on the itinerary of some projects. Perhaps the most significant of these is the "Museum as a Network of Networks" described in the announcement of the Reina Sofía Museum of Contemporary Art's programming for the 2008-2009 season:

> The characterization of the museum as a network of networks signifies affirming its condition as an open organism immersed in a dynamic of exchanging experiences, knowledge and resources. The "network" concept transcends the framework of simple collaboration among institutions and implies configuring a structure that makes it possible to share art collections as well as projects and professional initiatives. Building a networking dynamic implies opting for a system of confluences, dialogues, synergies and shared actions.

But a P2P museum of the sort proposed by Pedro and Rubén suggests ideas that go beyond a dynamic framework of relations. Applying the P2P paradigm to the museum structure signifies placing the museum on a horizontal map of resources in nonhierarchical networks without forgetting the relative importance of different nodes and force vectors that make those networks taut. Conceiving of a peer-to-peer museum would imply proposing a system of one-on-one relations between equals in which not only nodes (the different points) but also contents are organized on this horizontal web. And even when contents take place in a hierarchical manner a P2P system permits parallel relations in which none are blocked or annulled by others so that minority cultural productions can be made known, and can communicated with each other. Another idea that allows us to transfer the "museum" concept to a different space is connecting it with the new digital and networking context, as Gerardo Mosquera proposed when speaking of the museum as a hub. That is a metaphor closer to computer networking or commercial airline management but it illustrates a different and more dynamic way of managing a museum's physical and conceptual space.

> [...] We would have to think about museums as centrifugal rather than centripetal, transformed into a space where the world is shown an action in the world. Thus, instead of pulling art into a hallowed space, the museum could act right where that art is actually taking place. It would be a museum as *hub,* decentralized, in movement, spread all over; a dynamic entity that would simultaneously participate in a variety of projects in different places [Mosquera].

In fact, ever since its origin, the museum has been a sort of repository for artworks, a point of reference for study, research, creation and enjoyment that arose at a moment when the physicality of artworks was the aspect that most determined any action. However the updating of the museum in the new audiovisual context would involve connecting, decentralizing and opening (like open code) those repositories, guaranteeing universal access to its resources and a free flow of information and knowledge.

## <u>Communities: practices against essences</u>

JORGE LUIS MARZO
17 September 2008
9:26 h

Perhaps one of the ideas we most need to question when reflecting on "communities" is the frequent use of that term in an essen-

tialist way. Numerous activists, groups and networks congregate around the idea of "community" as if it were somehow "natural" and profoundly "popular", as if it were linked to an "uncontaminated" way of practising politics. That would be reason enough for it to be the object of counter-revolutionary scorn by the hypocritical strategies of current mainstream politics. Communities and networks are sometimes presented as places where a pre-modern way of practising politics has been preserved, a sort of Arcadian refuge in which the dynamics of discussion and application are projected thanks to good feelings and the absence of individualized strategies opposed to the harmony that reigns in a highly cohesive community. We can find examples of this in some of the appeals to rural communities by native people; in certain calls to networks created in neighbourhoods on the fringe of large cities; in numerous references to the relations generated by missionaries and aid workers in "frontier" zones of humanity. All of the cosmology surrounding this sort of "ideological El Dorado" hides a profound resentment towards negotiation, infiltration and camouflage, the sort of behaviour based not on essentialisms but rather on trial and error. Let me offer an example that should not be understood in its "naturalist" aspect, but rather for its "culturalist" nuance in a setting traditionally defined in a "natural" manner. In 1987, social scientists proposed a reading of social relations based on data collected through the observation of the behavior of mandrills. According to those studies, mandrills do not respond to relations that are already fixed in a stable structure, accepting a determined hierarchy in a group or division of domains. Instead, their relations with different members of the group are ruled by observation, calculation, testing, confirmation, negotiation and manipulation. Mandrills do not seek a specific type of society that could be considered natural or best. They find themselves with one they are constructing day by day and they use techniques and tools to deal with it. Rather than entering into a system of alliances, they test the availability, willingness and solidity of each alliance without being sure ahead of time which relations will endure and which will not. Thus, for example, in this theory the social value of domination by the strongest is not simply an effort in the struggle to establish a hierarchy, but rather a way of creating relations in which, of course, domination is an important value. Domination would therefore be more a tool than a structural model. Mandrills appear as social players actively negotiating and renegotiating what society is and what it will become. Given this data, the two scientists asked themselves: if there were really a previous structure that "you had to enter", one that would mirror our social relations, then why would there be all this behaviour designed to investigate, negotiate and watch others? By extension, they asked: isn't all this partially applicable to human society? Are we pursuing a determined model — written into our historical and social genetic code — of social life, meaning that everything we do is intended to comply with that mirror? Or is it all a concatenated series of trials and errors that help us discover our strategies in the perpetual negotiation that constitutes our relations with others? The implications of these questions for the fields of politics and economics are clear and substantial. Society is being built as its members act. Rather than seeking out the social link in relations among members, we should place the emphasis on how those members achieve such links in their social quest. Social life is shaped, expanded or contracted through the practices, trials, successes and errors of society's members. Why not apply this reading to the field of tools as well? Why not try to understand tools not as closed technical systems used only for specific purposes, but rather as systems in a constant state of becoming whose evolution is subordinated to what people do with them at specific times and places? And why not adapt them to our uses, that is, by updating our practices?

Network and everything that goes with it..., and 3

ARTURO (FITO) RODRÍGUEZ
22 September 2008
11:22 h

1. We think about the idea of “community”, of “collectives” and “networks” and we want to known what we are talking about; our intention is worthy and committed because it reflects an effort to explore an area we cannot ever know completely. It is ungraspable, intractable (I think the intention is rather candid, at least in my case) but we know that this area that is strange yet close to us, *is where meaning is generated.* And that is exactly why we know intuitively that we cannot stop thinking about these things. We cannot inhibit ourselves because our duty is to tighten the web, locate the nodes, establish the connections between our circumstance and the reflections of life “like ours” that reach us through the different forms adopted by information. Moreover, we want to think about this entire conglomeration of things precisely when it crashes against the breakwaters of politics. That is when we experience a series of sensations grouped under the general heading of anxiety and vertigo, and now, indeed, we find ourselves definitively alone in the face of the shadow of a paradox: what generation of meaning?

2. If it were true that, for reasons known to all of us, time and space have varied in the terms by they were known until now, then we should quickly, or not so quickly, think about what the coordinates of our situation would now be with regard to others, society, the “other” and so on. Given the supposed primacy of time (of speed as the new totem), we see how conflict is increasingly organized around space: immigration, occupation, expropriation. So if it were true that our project’s GPS uses the web to determine our true location, then we should have noticed the need for a political reappropriation of territories such as neighborhood, tavern and the living space. But someone has been altering our navigation devices, the compass went mad long ago, the horizon disappeared behind the smoke of factories and there is now a dull, constant buzzing when night falls...

> The fundamental difficulty that arises when we try to think about “the social” as a space (for anonymity) — and we have reached the conclusion that that is the only way to grasp it nowadays — is that space itself has always played a secondary role with respect to time [Mar Traful: *Miradas extraviadas,* chapter, “Where are we?”].

3. If the networks of global capital and those of global resistance have developed in parallel, sharing the same logic, techniques and strategy, what type of scenario must we invent for questioning this single pattern or method? If space and time dress up to look like each other, if they hide and stick together because of the network, and we cannot separate them when we seek out our own space or our moment, then what kind of action do we have to put into practice in order to recover the meaning and direction we want to give to our voyage, not to mention our *destination?* If the web can be a viral infection, and also a remedy, if it is used like a spice for cooking and for sex, if it is just as good for a goose as for a gander, if it is the sacred book *and* its exegesis, then where could we get something so powerful that it could carry all its meaning in a secondary role, at least for a mutually-agreed period of time? No wonder Spiderman is so compelling...

4. And finally, it seems that the construction of meaning, or of whatever is supposed to take its place, would have to involve a political reappropriation of the spaces of everyday life. But it also seems that this type of political intervention always has to be launched precisely by the form of politics that ignores those very spaces, as if

the capacity to transform were impossible outside the narrow sector it has defined. And that is when the deterioration of those spaces reveals how confinement and illegalization — to mention only two examples — have become common practice without there being any doubts or answers to these questions. That is when we discover that the coordinates of our situation, the ones we mentioned before, disappear, taking all trace of us with them, evaporating in the transition from satiety to indolence by way of incredulity in order to end up merging into the dull and constant buzz in the night.

## Resetting the system. The museum as repository

NATXO RODRÍGUEZ
6 October 2008
9:33 h

The different articles published here have insisted on the difficulty or impossibility of making ideas like "museum" and "network" compatible with each other in the way expressed, for example, by Jorge Luis: "like an independent tool for citizens". Fito even insisted that there is no need to update museum furnishings because they already fulfil a very clear function. He proposed turning our attention to other things, such as the design and application of respective cultural policies. All of this is true and I agree to a large extent, but I cannot help coming up against my own contradictions over and over again when I consider different ways of updating the museum as a resource, especially when most of those different ways appear to be not very viable at all. It is difficult not to think about museum furnishings as something that could be radically improved, especially in small places where, due to the scale of the context and the reigning cultural politics, they act like a sort of black hole capable of absorbing all available resources in their immediate surroundings.
I continue to think that it is not too late to reset the system in its most local dimension, adding new functions to the museum's furnishings. The ideas of a "network" as a tool and as cultural tissue should be the main objective. They are still useful and all the more so if museums continue to respond to public cultural policies. Still, we must be aware of the weight that traditional ideas of "collection" and "heritage" have, even in the smallest and most up-to-date new museums, and of how much they weight down any other approach. But different experiences of networks or practice in the area of free software offer us examples on a daily basis, such as the idea of "repositories" that would work like open, accessible, fluid and decentralized archives. Here, the term "open" (J. Freire) refers to "a high probability of being discovered, analyzed, used and modified by other users." In other words, once again, we must insist on the possibility of digitalizing contents and distributing them immediately over current and future exchange networks. Thus, it is never too late to launch a network to reset different cultural policies and act locally to apply them.

***Networks constitute the new social morphology of our societies and the spreading of their connective logic substantially alters the operation and results of processes of production, experience, power and culture.***

**Manuel Castells**

# The critical dimension of artistic practices in the web 2.0 system

Juan Martín Prada

What is called "web 2.0", the "social web" or the "participatory web" is characterized by a establishment of a business model based on participatory architectures, structured on myriad digital social networks (Myspace, Cyworld, Facebook, etc.), and new ways of generating contents by users through blogs and large collective repositories of shared files, used and expanded by millions of persons each day (YouTube, Flickr, Ourmedia, etc.). Today users have become the suppliers of the contents of the site they visit, to which they add value by increasing its files in an effective business strategy based on making passive consumption participatory, where users are both producers and consumers, that is, they become "prosumers."[1]

Therefore, the web 2.0 business model does not aim to make specific contents available to users; instead, it aims to manage the contents provided by users. The dominant companies' efforts are not focused on producing "data" but rather managing "metadata", as well as providing tools so that users can share, modify and create new contents.

The goal today is to produce communities of volunteers, to exploit our desire to socialize, to share and exchange our photographs, videos, comments and opinions, in making money out of our need to feel we are part of a community, given that production in the web 2.0 model is based on designing forms of human relations. What the new business corporations produce is mainly social life, personal relations, where affective and economic factors are constantly overlapping and indistinguishable.

Of course, users' motivation to take part in and cooperate with this system stems from many necessary elements and conditions, all of them more or less related to "social emotions" (friendship, company, solidarity, empathy, etc.). In that sense, an essential role is played by what is designated *ego-boost*, that is, the pleasure obtained from public recognition of one's volunteer work, the satisfaction of feeling that we are of use, of being able to help or communicate our enthusiasm to others by sharing what we like or consider funny, interesting or valuable.[2]

There is no question that, in statistical terms, the immense majority of the videos and photographs posted in those vast collective repositories, generated by the huge "social fabric" made up of users, are nothing but poor imitations of professional creations or merely curiosities, jokes, or recordings of such personal moments and situations that they can hardly interest anyone but their authors and their families and closest friends. In fact, though it is tempting to consider these repositories of files as examples of the longed-for socialization of audiovisual creation, many see them as the paradigm of a new aesthetic oclocracy or mob rule, in which any professional criteria for determining value would be neutralized. Certainly, underneath the statements of web 2.0's detractors are echoes of the negativity spread by Jean Baudrillard when he said that what people want is "a spectacle of banality, nullity, insignificance and flatness."[3]

In contrast to these views, however, we should recognize the potential scope of creative and social opportunities that the web 2.0 model has opened up, for we are constantly surprised at the inherent possibilities of the infinite multiplicity of active individuals who participate as the producers of all those videos, photographs and comments, the desire of those millions of people to enjoy sharing and socializing, and the enthusiasm pouring out of the images they contribute. The immense human energy that makes the dizzying development of platforms such as YouTube or Flickr possible is probably the best example of what those desires for enjoyment, encounters and socialization on the webs is capable of achieving.

However, the fact that all those platforms depend on the interests of the large Internet corporations that manage them could be an excessively powerful obstacle to believing in a true fulfilment of those potentials. The communicative homogenization imposed by carefully predetermined interaction and valuation formats, various strategies for including advertising, and the different types of censorship they allow are only some of the major drawbacks.

On several other occasions I have stated that in the powerful emergence of all this amateur creativity, the traditional distinctions between "professional" artistic practices and those that do not aim to be artistic or are purely amateur would be a matter of nuances related to the intensity with which each creation reveals and expands the potentials and essential aspects of life and of critical consciousness that are possible in that connected multitude. That is because, really, the

most interesting artistic proposals in web circles today are no more than an anticipation of the constitutive power of the connected multitude, that would give concrete form, in the uniqueness of the artwork, to the common factor underlying that multitude: an aspiration toward a fuller, more pleasurable life with greater solidarity, the desire for a more deeply experienced and open communication, of a society that is more cohesive, not via homogenization but rather through the integrated inclusion of differences.

Therefore, one of the most significant commitments in that ambitious form of resistance we call "art" in the context of this second phase of the web would be, precisely, to design ways to transform the model of critical thought associated with what we understand to be "artistic behaviour" into a model of social and communicative interaction.

Undoubtedly, the allegorical, interpretive and subjective elements of "art" have a great capacity to carry out a promising poetic reconfiguration of the communicative interactions that occur in the connected multitude. Thus, from the second phase of "net art". We can expect new criticism of the production dynamics of meanings that operate in the networks, of their forms of exclusion, of their contradictions, and of their procedures of economic exploitation of affective interactions. In fact, recent proposals in *net.art* appropriate the new digital social networks, participation platforms and meta-verses as new reference contexts. The blurred boundaries between art and activism, creation and dissention are travelled once again in many different ways by new form of on-line artistic creation.

Having understood this new phase in *net.art* as the most creative dimension of the exercise of dissention within the context of web 2.0, we could characterize this set of artistic practices as ways of exercising an interpretive and critical opposition to the new dependencies and needs that organize the web today and that manage its business models. It could also be seen as the ideal way to develop alternative forms of valuing the prevailing habits of linguistic exchange, collaboration and collective participation that are integral to the "social web."

In sum, what today's most socially aware *net.art* would aim for is: to rescue (even if in a way that is only sporadic, merely propositive or even purely testimonial) communication and social experience from their permanent colonization by the economic interests of large Internet corporations; to open new possibilities for the development of an experience of the web that is not unidirectional or coactive, but rather open and interpretive, analytical of the lifestyles imposed by new business strategies. With these core issues, these art works demand we make an effort to interpret, above all, the systems for the way the web 2.0 system works technically and socially, and the procedures for socialization and the production of subjectivity that it predetermines and economically exploits.

And perhaps we can state that the role of creation most involved with social and political reflection lies in its ability to overcome a certain incommunicable character of social struggles in networks, where everything seems legitimized being based on terms such as "participation", "share" or "social network". Any type of effective dissention that comes up against them is easily silenced. Probably, critical thought integral to artistic practices can help us to better understand what can be considered truly "social" with respect to new technologies and applications that, as occurs in the context of web 2.0, are always pre-

sented to us as intrinsically "social" media. The fact that, on today's web, it is increasingly difficult to distinguish between sociability and economics, between validity or a field of meaning and corporate interests, would explain that one of the main purposes of the most critical artistic practices today is precisely that of revealing that distinction from the field of aesthetic interpretation.

Perhaps the most significant aspect of the evolution of the web 2.0 system is the popularization of the use of new devices and applications linked to geo-localized data. GPS (Global Positioning System) devices have become cheaper and are now included in mobile telephones and photographic cameras at a proliferating rate along with the increasingly intensive use of geo-navigators (like Google Earth, NASA World Wind, Microsoft Live Local 3D, etc.) and other geographic information web services. In addition, the development of open source type "geo-programmes" is now massive, with numerous cartography tools based on "open standards" and "open-data" geographic services, which herald fascinating paths in this new link between digital networks and physical space.

This all means that today we can speak of the consolidation of a "geo-spatial web" made up of this whole set of applications and web services for the management and production of geographic data. The growing emphasis on the relationship between information and place constitutes one of the most decisive factors in the evolution of the participatory and social character of the Internet. In fact, the treatment of information related to specific place, geo-tagging, and geo-referencing for photographs, videos, comments, etc, that users share on the large web 2.0 platforms are more and more usual. Collaborative geographic localization and annotation are generating today fabulous open on-line maps, in which every moment, thousands of files and experiences of all types are geo-tagged, creating new strata of data superimposed on real space. As a result, the web is no longer a merely "virtual" space, disconnected from the physicality of the places we inhabit or through which we transit. The continual "urban development" of web spaces offers an opportunity to reflect of forms of "lack of urban development" that occur in non-digital space.

In an increasing recognition of the falsely trans-border character of the Utopia of global networks (one has only to take into account the censorship carried out on some Internet search engines in certain countries, or the prison sentences many bloggers are serving in places where freedom of expression is severely restricted), emphasis is being placed now on the possibilities of the networks for developing a more participatory urban planning, to reactivate the socializing possibilities inherent in the physical proximity of users, which implies sharing a common space, the same environment, be it a street, a neighbourhood or a city.

In this derivation of web 2.0 toward the spatial contextualization of all contents, a primary role is played by the expansion of "hyper-local" journalism, fundamentally based on "place-blogs", focused on geographically contextualized knowledge. With antecedents in the frustrated attempts led by the "digital cities" of the late 1990s, some "place-blogs" have nonetheless become epicentres of an extraordinary participatory dynamism that is tremendously revitalizing for spatially localized communities (from those made up of neighbours on the same street to those made up of residents of small or even medium-sized urban centres). Today "place-blogs" comprise the essential core of an emerging "local web 2.0 local."

Inevitably, this progressive link between digital networks and physical space is accompanied by the development of a whole set of new artistic practices that explore on-line and off-line relationships. Arising around new geo-localization applications on web 2.0 as well as breakthroughs in "pervasive computing" or "ubicomp", this new trend in "networked art" delves into not only the possibilities of taking action around the centres, points and nodes that comprise the organizational and communicative structures of telecommunications networks but also (and primarily) their relationship to the space of streets, squares and cities, "expanding it", redefining the potential interactions that can take place there, exploring the relationships among the synchronicity of persons on a temporal level and as they coincide on a spatial plane as well.

And perhaps artistic practices linked to "locative media" and the applications of "local web 2.0" are the best example of a critical response to the globalizing de-localization that we considered, up to now, as integral to the experience of the Internet and the social relations that took place there. Certainly, through all kinds of applications and web information and geographic data management services, mobile and wireless technologies, and devices for "location-aware computing", the manifestations of "locative art" take part in the physical spaces for communication and relationships among people. With strategies for mapping, geo-annotation, mobility, and mixed reality games as a base, a series of poetics of localization are being developed that lead to a great variety of experiences, in an always complex and diverse negotiation of on ine and off-line situations, proposals that probably merit being described as authentically "topo-critical" initiatives.

Of course, the practices of "locative art" offer a new approach to public art, removing any aspect it had of colonizing the space, and use urban and rural environments, without subjecting them to its presence. The most interesting cases lend the maximum visibility to the impetus for group participation in urban space, emphasizing what is public about it, showing us new possibilities offered by artistic thought in alliance with the participatory technologies of the networks, to reconsider our notions of what it means to "inhabit" and "share."

**Notes**

**1** *Prosumer* is a term that means a consumer who is also a producer.

**2** It is worth pointing out the relationship between this satisfaction and the term "self-efficacy", developed by Albert Bandura in works such as *Self-efficacy: The Exercise of Control*, W.H. Freeman, New York, 1997.

**3** Jean Baudrillard: "L'elevage de poussière", in *Libération,* 29-5-2001.

## On the Internet (a few loose thoughts)[1]

José Luis Brea

**Certainly, Internet's true peculiarity is that it offers an absolutely unprecedented conversational situation. Speech is not involved — even in verbal "chats", the voice's own words are mediated by a deflector that synthesizes them — and as a result, any illusion of stability in the economies of production or transmission of meaning is completely eliminated.**

**Even when chatting is done in what is supposedly real time, an inevitable lag appears between each transmission and reception, thought and typing, sinking any illusion of simultaneity in the abysmal depths of oblivion.**

**The websurfer navigates the routes of the signifier, in full knowledge of the unbridgeable gap that (still) separates them from those of meaning.**

**In other words: the one who "speaks" on the web is not where "his" word is; he lives in an unsurmountable delay with respect to it. The word that circulates is always anonymous, writing without a subject. What it says, it says alone — totally lacking the supposed subject that enunciates it.**

**A chat is a game for late surrealists — producers of genuine *cadavres exquis* — dedicated to the succulent experience of discovering how a text speaks by itself as it circulates, and whether, in circulating, it "pronounces them."**

**So here, it is never a matter of words, but of text. Not a question of *logos,* but of *graphos*; not of the verb, but of writing. Writing exchanged in a regime that is somehow archaeological, native, and of an anthropological order. The regime in which signs are still exchanged like objects in their dark, splen-**

dorous materiality. Not as bearers of meaning, yet, but first and foremost as proof of interconnection, a free establishment of links between similar beings, between the "whomevers" of a community constructed precisely for that rite.

The websurfer is a neo-primitive dedicated to re-experiencing bartering, the primeval ritual of the gift.

The gift exchanged on the web is the sacred gift of writing, the primeval graphos. It is remote, primary writing, a writing of *gramma,* a writing of signs that we could not differentiate from pure image, from pure graphic gesture. On the web, writing and image enjoy the same status — each is experienced in the same way. They come to us as dispatches from afar, materiality filled with "intention" rather than meaning, will rather than representation, like effects charged with a principal finality: that of bearing witness to the existence of the other. Our first glance drowns in the recognition of that graphomechanistic, libidinal quality that is intensive, mute and material.

Then we can begin to read, or not. If not, dedicated to the undifferentiating experience of the pure surface and visuality of signs, we can "look" at texts the way we look at images — as proof or tracks, mere signs of the others' existence.

Surely the medium's maximum subversive potential lies in that property. On the web, the collision of the regimes of the image and of writing is absolute. Their subversion is reciprocal. The web distances writing from the word — from meaning as a given — but it also distances the image from its innocuousness, from its value as representation. What also becomes clear here is that, like writing, images have to be read and interpreted an infinite number of times. No gaze, no reading, can exhaust them.

The very nature of writing — which emerges even more clearly on the web, as long as the device called "book" does

not burden it with a temporal unidimensionality that imposes a single axis of legibility — is multidimensional, it expands in various directions that can be reconnoitered without a predetermined order. It is the power of the word and its embodiment as sound in time that impeded perception of the multidirectionality characteristic of graphos: a writing that explodes in all directions and connects in all directions, a writing for which there is no before and after, for which space is not a determinant of order, but rather a potentiality for encountering.

What astonishing force an image would have if, like writing, it managed to encounter the possibility of developing in that way: multidirectional rather than successive, open rather than static. On one hand, all the power of the fixed image — the "plastic" image — whose refusal to "occur" in time loads it with an extremely powerful inner potential, an existence outside time. It lives in the time of its meaning, which later readings will have to open. On the other, all the power of cinema, of narrative — but no longer subjected to the unilinear axis of duration of things happening (since they happened in the same place, until now, some had to happen first and others afterwards). But that is over — and therein lies the greatest metaphysical potential of the web.

The web makes the world transparent, completely draining away its secrets — and the hacker, like a new figure of the most subversive sage, makes it his job to insure the penetrability of every place. No form of encryption or security code impedes the most absolute transparency. All data, all the world's knowledge, is accessible to this new incarnation of the Absolute Spirit — this new avatar of the World's Encyclopaedia — the web. In exchange, the web must insure — even though it lies in doing so — the full anonymity of the user.

**Surfing the web does not have to do with discovering, with true discovery, but with its exact opposite: the experience of pure searching, of not finding. It has to do with the experience of infinite interpretation, of interminable reading, which the web feeds as a machine for multiplying readings and for the proliferation of texts and signs.**

**The web is the very map of the dissemination of knowledge and, in its untreatable contemporary obesity, it makes any pretension of an overall grasp or centralization implausible.**

**Therefore, in the face of the web, it makes no sense to propose a political horizon defined in terms of some sort of "ethics of communiciation"— what we could call a sort of "democratization of the new order of information" or the like. The political significance of the web lies in the recognition that, instead, its own nature implies an "ethic of interpretation"— or to be more precise, of the "irreducible multiplicity of interpretations."**

**The web's political potential lies precisely in its capacity to subvert any pretension of veracity in communication or information, showing that the condition of any effect of meaning is that of merely handing itself over — unfinished — to the infinite play of all possible readings, of all possible interpretations.**

**Note**

1 Fragments drawn from the chapter "Sobre la red", from the work *La era postmedia. Acción comunicativa, prácticas (post)artísticas y dispositivos neomediales*, Centro de Arte de Salamanca, Salamanca, 2002. A PDF version of the book can be downloaded free at: <http://www.laerapostmedia.net>.

# The web generation: the power of “us”

Imma Tubella

> The vision I have for the web is about anything being potentially connected with anything. It is a vision that provides us with new freedom, and allows us to grow faster than we ever could when were fettered by the hierarchical classification system into which we bound ourselves (…) and it brings the workings of society closer to the workings of our minds. **Tim Berners-Lee, *Weaving the web***

An ancient Japanese proverb says that no one of us is as clever as all of us; in other words, “we” are more intelligent than “I.” This has always been true but now more than ever: in the “network society”, it is of vital importance. Networks constitute the new social morphology and their logic substantially alters the workings and results of production processes, experience, power and culture (Castells 2003).

The web is a collective medium by definition and in the “network society”, the degree of collaboration among individual minds is growing exponentially, producing an effect similar to Lorenz’ “butterfly effect”, a name based on the ancient Chinese proverb which states, “The flutter of a butterfly’s wings can be felt on the other side of the world.” The butterfly effect is one of the behavioural characteristics of a chaotic system, quite similar to the system of networks in which variables change in a complex, self-organized way, making predictions possible only up to a certain point.

The increase in human interactions — personal, social or institutional — through networks is concentrating and increasing the power of us. The key word today is connectivity, always accompanied by collaboration and cooperation among equals. In the “network society”, we must share and work together, or else we’ll disappear. It is a paradigm shift, a new form of production that entrusts the creation of economic, cultural and social value to the larger collective. One example is Linux, a programming system perfected by thousands of anonymous programmers who contributed their work free of charge. Nowadays, cooperating is profitable and, in addition to producing value, it is free.

Linux, MySpace, Facebook, Wamba, Hi5, Tuenti, Wikipedia… Millions of people use and “live in” the web daily, to work, study, play, amuse themselves, socialise, create, disseminate, buy, sell, and solve problems: in sum, to communicate, immediately and in real time, regardless of the distance. Only fifteen years ago, to communicate with anyone not physically near us, we had to use the telephone, which was very expensive, or the post, which took at least three days. Do today’s young people even know what a stamp is? I’ll ask that question in my next survey but I dare say they may know because

they have used them in a virtual game, but I'd be surprised if any of them had stuck one on an envelope.

Young people are spearheading the change, true citizens of the "network society". Not limited to trying to define or criticise it, they simply live it. We grew up with television and generated theories about it. Growing up with the web, they find it ironic that we attempt to theorize about it. That is because the majority of us — or at least, those who work in the field of communication, as I do — find it quite difficult to forget the cultural studies of the 1960s, and continue to obsessively analyse the perverse effects of television on children. We can continue to do so if we like but the number of children who amuse themselves watching television, or only television, is decreasing.

Our children and young people are the web generation and perhaps we should take a more in-depth look at their new habits, forms of relating to each other and constructing reality. If we do not, their world and our world will have little in common. They are the active creators of a new digital culture, new cultural practices. In contrast, we still hold the older generation's typically contradictory attitude to youth, with the additional ambiguous attitude, in some cases of insecurity and fear, toward technology. Our children have ventured fearlessly into cyberspace. They have explored it bravely and creatively. They are the new pioneers. We respond with a combination of admiration, fear and perplexity. On 8 February 2004, the *New York Times* dedicated its front page to them, wondering whether they were artists, vandals or technological saboteurs.

### Uses of the Internet

What do the data show? In the United States, the latest Pew/Internet report on adolescents and social networks considers Internet use universal among young people from 12 to 17 (93%). In Spain, according to data from the National Statistics Institute (INE), the percentage of users from 10 to 15 years of age is over 85%. In Catalonia, according to our data, that percentage is 90%. The Pew/Internet report shows that the creation of contents for those ages continues to grow. 64% of young people in this group have created at least one type of content and posted it on the web. In 2006, that percentage was 33% (35.5% in Spain). In the United States, girls are more active on the web than boys: 35% of girls have a blog with regular posts compared to 20% of boys, and 54% post photos compared to 40% of boys. In contrast, boys post over twice as many videos. The report points out that creating contents is not limited to sharing them but includes discussing and improving the creations on the web. The study shows that there is a category of super-communicators comprising 28% of all U.S. teens, and the majority are older girls. 39% of teen users share their artistic creations, such as art projects, photos, stories or videos. 33% create elements for or work on others' web sites or blogs. 55% of this age group has a profile on a social network like MySpace or Facebook. 70% say they read blogs assiduously and 76% add comments.

The report contradicts many stereotypes. For instance, teens from lower income and/or single-parent families blog more. The adolescents who are most active on the Internet are also the most active outside the Internet. Those who create

contents on the Internet are not limited to that sole activity. They also participate in on-site activities and have an easier time finding a job. Thus, the Pew/Internet report shows that participating in the network of networks is correlated to participation outside the Internet, which disproves the myth that the Internet isolates people. Tim Berners-Lee (2000) says the web is a structure that enables us to overcome two catastrophes: the uniform, global, McDonald's monoculture and the isolation of cults and sects that only understand themselves.

In relation to participation in social networks, the most significant Internet phenomenon at present is that 83% of Spaniards between 14 and 22 years of age are active in at least one social network. This data published by Xperience is supported by studies carried out with focus groups. It is worth pointing out that in the last survey we did at the UOC on uses of the Internet in early 2006, the thought of asking about belonging to social networks did not cross our minds because we were barely aware they existed. MySpace was born on 6 August 2006, and two years later, on 19 August 2008 at 1 p.m., it had 241,816,916 members and 300 employees, growing at an average of 230,000 new members per day.

## Anatomy of the knowledge society

The literature on the anatomy and structure of the Knowledge Society includes theoretical approaches from complex disciplines, such as neurology. In his book *Weaving the Web,* Berners-Lee writes that the web's structure is not based on trees or matrices. Although the human mind organizes information that way, it is able to break down structures, make intuitive leaps and all kinds of connections to break down barriers and build meaningful associations that help it to reason. In building the World Wide Web, he attempted to imitate that way of working, developing connections exponentially as the brain does when fully engaged in the learning process. As occurs in the neurological system of an organism, the web needs to evolve, to establish more contacts and connections. The structure is what really matters.

We have billions of neurons in our brains, just as there is an almost infinite amount of data on the web. However, in both cases, there is no knowledge if there is no connection. This is a defining factor. The nervous system is not rigid; instead, it transforms and evolves over time thanks to multiple, changing interactions carried out at all levels. It is as if the web were discovering a way to imitate a physical, biological body within a social setting. In that regard, Sakata and Yammamori (2007) have shown topological similarities between the brain and social networks. Both systems share similar organisational principles and a common value: reciprocity. They both learn and correct themselves.

Neurons make it possible for cells to communicate over a distance, and integrated circuits or chips connected by wideband channels are the neurons of social networks. Communication — that is, meaningful, aware communication — is the foundation of our society and culture, and the instrument we use to build our identity.

Physicist Fritjof Capra says "ecological literacy" means understanding the organizational principles of ecosystems and using them as a model for creating sustainable human communities. Capra has identified five major principles of

ecological literacy: interdependence or connected independence, flexibility, diversity, cooperation and bio-mimesis. The term bio-mimesis means the tendency to imitate nature in rebuilding social systems, and is implicitly present in the work of neurobiologist Giacomo Rizzolati published in *Nature* in late 2005. I consider his work of special interest because of the parallelisms established between mirror neurons and the Knowledge Society.

In the late 1990s, Rizzolati's team — he is head of the Neurology Department at the University of Parma — was studying the brains of a primate species when they discovered a group of neurons activated not only when the monkeys performed certain movements but also upon seeing others do so. The researchers called them mirror neurons. Initially, they were thought to be simply an imitation reflex but with time, it was discovered that mirror neurons enabled making others' actions, sensations and emotions one's own. Thus, mirror neurons reflect the activities of another being, and also put you in their place.

Vilayanur Ramachandran, a neurologist known for his work on behavioural neurology, has said that the discovery of mirror neurons will be as significant in the field of psychology as DNA in biology, because the foundation of our social behaviour is the capacity to feel empathy for others, given that it facilitates the need to connect, collaborate and share. According to Rizzolati, mirror neurons are activated even when the action is not seen, but only imagined mentally. In contrast, Damasio and Meyer (2008), neurologists at the University of Southern California, believe that neurons that serve as hubs (convergence-divergence zones, or CDZ) activate neural networks. That is, what is produced is not a mirror effect but rather, when stimulated, they weave a network similar to the received stimulus. Thus, the CDZs, in connection with other CDZs and their ability to gather and distribute signals learned from experience, allow the brain to reconstruct an action based only on the knowledge of part of the story. What makes this reconstruction and comprehension possible are the connected neural networks interacting, not a sole group of mirror neurons that provoke a series of mirror actions. In any case, mirror neurons pull on the "puppet strings", which are wide neural networks. For Damasio and Meyer, the network is what matters, not the neuron. Their studies and reflections on the functioning of the brain offer a valuable contribution to the study of the behaviour of social networks, and are quite similar to the work of Berners-Lee and his team on the evolution of the World Wide Web, the semantic web and their collaborative work groups.

## Human being, social being

The most significant message of mirror neurons and puppet neurons is that they prove that we are social beings, that human beings are meant to be in contact, to respond to others, to build themselves in relation to others, and that society, the community and the family, in the broadest sense of the word, are truly innate values. The Catalonia Internet Project (PIC), the study I co-directed with Manuel Castells carried out from 2002 to 2007, revealed that what those surveyed identified with most among 12 choices (self, work, gender, nothing particular, family, age group, culture, language, humanity as a whole, religion, country or nature) was the

family, among all ages. Thus, "family" appeared in 56% of cases, followed by the category "self" in 8.7% of cases, and "nothing particular" in 5.4% of cases. The rest was so fragmented that it was not significant. The result surprised us and we attributed it to the need people have at times of crisis- currently, the transition from one society to another- to fall back on what they know. Now, I imagine that Manuel Castells would agree with me that our interpretation would be different and would involve the logic of networks. On the web, we have access to the contents of other people's imagination and memory. Our computer screen becomes a space where our own imagination, memory and intelligence connect with others' and they start working together. Marvin Minsky speaks of the "society of minds", Kevin Kelly of the "hive mind", Howard Rheingold of "smart mobs", Derrick de Kerckhove of "connected intelligence", Albert-László Barabási of "intelligent networks", and Pierre Lévy of "collective intelligence". The web is a social construction much more than a technical one.

Society in the 1980s and 1990s tried to deny that we were social beings and promulgated individualist values: the Self as the basis of everything else. Our youth has rebelled. Far from being isolated at a screen or in danger of being so, the data clearly show that today's young people are more social, more loyal to their peers and better equipped for teamwork. In addition, they are able to take more sophisticated decisions and they possess abilities gained from Internet searches and on-line games that we are not even able to comprehend. Studies are beginning to appear showing that Internet searchers are more highly valued in their jobs than non-searchers (Beck and Wade, 2006).

> Games give us the freedom to be, think, do, create and destroy and they allow us to change the answer to the question "Who am I?" as often as we like and in a hitherto unimagined way (Beck and Wade, 2006).

We should start to reflect on what effects this cultural storm will have on our culture, an ambiguous concept but one that is impossible to understand without an interdisciplinary approach. Culture is not something that I know but rather something *we* know, and it outlives any individual member of a community. Knowledge has meaning within a group: the concept of a "pig", for example, means food to some cultures, but poison to others, just as bread with tomato is basic everyday food in Catalonia, but merely wet bread in some other places.

Our young people are growing up and becoming accustomed to living in a world of networks with multiple butterfly effects. Their experience is nothing like ours. 18 years ago, my ten-year-old son had the opportunity to enter the cockpit of a plane about to land in Los Angeles. He asked the pilot about the weather forecast, as he already knew we would land on one of two runways, each requiring quite different approach manoeuvres, depending on the wind. For him, landing in Los Angeles was a daily routine. He had a simulator that was very similar to the one used by pilots at that time. Growing up has changed. Young people, instead of recurring to imitation, as was traditional, are now placed at the centre of the action. To get there, they have had to practice a lot and fail often. Perhaps that is why they handle failure better: after all, their success was based on multiple failures. The web generation knows from experience about the power of *us.*

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# Networks of users and free knowledge

Javier Echeverría

## 1. Power in knowledge societies

In the modern age, organic metaphors have been used predominantly to represent and model societies. Hobbes conceived of the State as an organic body. Ortega y Gasset spoke of giving Spain a vertebrate structure, as if it had a head, trunk and extremities. Monarchs and their governments were traditionally considered the brains or souls of their countries, according to the vertical concept of the *Res Publica* theorized by Plato that has prevailed for centuries. The monotheistic theological basis for these metaphors must be pointed out, in which power, knowledge, and order always come from above, from the heights.

The democratization of some societies during the modern age has brought some horizontality in the genesis of power, never more evident than during the ritual of elections, when candidates for elected positions go out on the streets, down to ground level, to ask for voters' support. In modern democracies, citizens have that power,

as their votes represent the general will and comprise the future of each society. That does show some horizontality in societies, but only to a certain extent, given that hierarchies and other forms of power continue to reappear. However, each citizen's equal sovereignty and freedom are affirmed, theoretically at least, by constitutional principles. And that is no small achievement, compared to theocratic governments, military dictatorships or absolute monarchies.

This long democratization process of political power has no parallel in relation to the power of knowledge. It is true that certain members of the Enlightenment (Condorcet) and the French Revolution instituted the principle of universal compulsory education, thus contributing to the widespread social dissemination of scientific, humanistic, and artistic knowledge. However, this increase in literacy among the population, which was remarkably successful in the 19th and 20th centuries, was based more on the distribution and use of knowledge than on its production. "Genuine knowledge and works of art are created by geniuses, by great men." "Genuine creators have always been, are, and will always be few in number."

Those are the beliefs of proponents of an elitist model of knowledge. They see the production of significant knowledge as the job of a select few: the wise, the best, based on merit and ability. The rest of us, the "little men" (not to mention women), have an opinion (*dóxa*), but no knowledge (*epistéme*). Public opinion is made by all, but only a select few create and manage public *epistéme*. In the most developed societies, where techno-science and informational economics have arisen, there are *aristocracies of knowledge*. At best, an attempt can be made to keep them open, so that anyone can gain access to them, provided that the person makes the corresponding effort to be admitted into those aristocratic knowledge communities, passing the tests, rituals, and personal standards prescribed by those communities.

In sum, restricted communities govern the world of knowledge because they are *experts in the matter,* in accordance with the model of scientific communities based on a strict distinction between one's peers and those who are not ("peer system review"); that is, between experts ("connoisseurs") and laymen. It should be noted that the use of the term "layman" in reference to knowledge proves that the old theological-priestly tradition still underlies this worldview, which assumes that knowledge ultimately comes from God and should be managed by a select few, who have been anointed for that purpose.

In general terms, that is basically the way the "state of knowledge" is, and its generation, distribution and use. It is remarkable that the majority of scientists also believe *that's the way it should be,* and demand that excellence and elitism be promoted by scientific and educational policy. Some people have knowledge (for example, because they have made an effort to achieve it) and others don't. *Ergo*: what is said or done by the former is worth more than the latter. To paraphrase Teilhard de Chardin and Sáez Vacas: the existing hierarchies in the noosphere are in accordance with the natural order of things.

There is no doubt that those who support an "aristocracy of knowledge" have powerful arguments in their favour. However, the arguments of those in favour of a *democracy of knowledge* should also be considered. This debate is quite relevant if we intend to address the matter

of power in knowledge societies, which is undoubtedly one of the major issues of our times. Those societies can be governed in a way that is more aristocratic (a culture of experts) or more democratic (a culture of citizen participation). Between a maximization of expertise, at one extreme, and a progressive increase of public participation in decision-making, at the other, there are many intermediate positions, and one of them is sure to be the most reasonable. However, albeit for heuristic reasons alone, it is worth looking at a complete contrast between the two positions to clarify the topic and explore it in more depth.

In any case, a reasonable consideration of these matters must leave organic metaphors aside. If we conceive of knowledge societies based on organic metaphors, we are surreptitiously including verticality and hierarchies as "natural" forms of organization in those societies. The paradigm of the "network society" (Castells, 1996-98) makes the organic metaphor paradigm that is so prevalent in the social sciences look ridiculous.

### 2. Networks of knowledge, deterritorialization and democratization

The paradigm of a network-society also questions another form of societal organization that may be even more deeply rooted than the organic metaphor paradigm: *the territory-based concept of societies*. Territories are pre-existing, like Mother Earth, and societies and states should be organized based on them. This territorial prejudice is something not even modernity or industrial civilization has been able to uproot, despite an affirmation of a cosmopolitan and international outlook. In contrast, the emergence of information and knowledge societies poses a challenge to the predominance of the industrial economy, to the point that there is talk of a post-industrial society (Bell); moreover, social groups and movements tend to be organized in networks, bringing into question the territorial principle, which has long been a determining factor in the definition of states and markets, and therefore, in the organization of power. It marks a profound structural shift, because it presents a different potential form of social organization, one that is reticular. Compared to body-societies and territory-societies, network-societies function quite differently, providing many more opportunities for the democratization of knowledge.

The organization of "network society" is based on interconnected networks that overcome territories. Territories have traditionally determined the basis of social structure: villages, counties, countries, nations, international relations, etc. In the "network society", however, *power is based on knowledge*, which is not tied to a territory; instead, it flows through telematic networks, which are usually in the air or buried underground. Knowledge flows over the telematic networks and power is held by those who control and own information.. They are the *Masters of the Air* (Echeverría 1999): the large multinational corporations that produce, develop, and distribute ICT technologies. These new socio-economic agents that arose during the last two decades of the 20$^{th}$ century, jointly with national governments, play a determining role in the *governance of electronic space*. There is another type of agent: networks of users of ICT technologies.

The World Summit on the Information Society (WSIS) organized by the UN (Geneva 2003 and Tunis, 2005) made very clear who the major powers with a significant role in governing the new form of society are: national governments, international organisms, top companies in the ICT sector, and, "last but not least", the civil societies of the world, which were present and quite active in the debates at the world summit. Nations and international organisms have a clearly territorial structure, for they arose during the modern era from industrial societies. In contrast, ICT users, who comprised the "civil societies" at the UN summit, are already organized into networks, as are multinational ICT corporations. As a result, "network-companies" and "network-communities" (or "network-groups") have come into being. The former compete for the market and try to dominate it. The "Masters of the Air", as we call them, comprise the "aristocracy of electronic space", and they manage to have the best experts at their service, be they scientists, technologists, artists, propagandists, or social scientists. In sum, more than anyone, they embody the "culture of experts", given that they have hired the best people in every field of knowledge for their R&D departments. The traditional power of nation states has been forced to yield to the emergence of this new form of power, based on technological innovation and especially on users' acceptance or rejection of various ICT technologies. This is how a new form of *démos* has arisen made up of network citizens, foreshadowed in some ICT users' networks such as communities promoting free software.

The "Masters of the Air", in fact, manage not territories but techno-social networks, in which the technological rules, symbols and patterns imposed by those networked, multinational corporations are valid. The users are, shall we say, the "populations" of those network-domains, and contribute to the success and power of the multinational corporations or holding companies behind them. In the Information Society, audience and user ratings for channels and technological platforms determine market share for each company. A "Masters of the Air's" top priority is increasing his *e*-population: the number of regular users. Telematic networks are superimposed over territories, so the objective is no longer to control territories: it is to dominate the networks. In a digital and electronic world, that is a succinct description of the power struggle.

However, users can also be proactive and form their own network-groups, regardless of age, gender, or the place or territory where they live. Today's "social networks" in electronic space are comparable to a certain extent to what was called "civil society" in nation-territories. The "Masters of the Air" — who innovate to be more competitive and increase their *e*-populations — have the most technological power. However, users are forming a type of counter-power that is gaining strength. That is why, in general, the democratization of knowledge should be analyzed based on the study of relations between multinational corporations in the ICT sector and the users of those systems and technological platforms. The debate on whether knowledge is being democratized or not must take into account the emergence of *user networks* who are also generators of knowledge. The aforementioned people who may democratize knowledge are part of these social groups, having lived with and experienced "network culture" from a very early age.

## 3. The power of networks of users

In his book *The Sources of Innovation* (1988), Eric von Hippel (MIT) showed that users, distributors and suppliers are also sources of innovation, which is not limited to manufacturers and producers of goods and merchandise.[2] He also pointed out that other potential sources of innovation exist, in addition to those mentioned. His innovation theory, usually called "distributed innovation", is an open model. The model, not linear or vertical, but rather is horizontal, or at least transversal. We recommend "pluralistic innovation models" that recognize the existence of a plurality of innovation sources, and therefore, of knowledge.[3] In knowledge economies, innovators are not only knowledge producers (scientists, engineers, IT specialists) but also the suppliers, distributors and users of that knowledge. This is all crucial in defining models for the governance of knowledge societies.

In his most recent work, *Democratizing Innovation* (MIT Press, 2005), von Hippel points out that users of products and services produce over twenty five per cent of innovations that are subsequently adopted by society. *Leading users* are a major source of innovation. Companies not only manufacture and produce goods and services in their own sector; they are also users of products created by other companies and sectors. They can be innovative as users, not only as producers of technological goods and services. Many companies engaged in the supply and distribution of goods manufactured by others become more competitive through innovations in supply and distribution. They often turn into manufacturers of the products they distributed, or add their own logos to those products. The diverse range of innovative agents and areas must be identified to obtain a broader, more precise vision of what is known today as the "culture of innovation". Although an in-depth analysis of the topic is beyond the scope of this article, it is worth noting that, in addition to technological innovation — the focus of most studies of innovation conducted over the past two decades (Oslo Manual, OECD, 1992 and 2005), we now speak in terms of "social, cultural and artistic innovation". As networks of users are formed freely in various social sectors, some begin to generate knowledge or activities that are successful socially, culturally or artistically. The evolution of the Internet towards what is currently called web 2.0 or even web 3.0 tends to enhance free interrelations among users, including social networks and P2P culture. Free software communities promoting free access to and use and modification of knowledge head the entire movement. For that reason, they are the subject of the final section of this article.

## 4. Free knowledge networks

This is the canonical example of a knowledge network comprised by users, which illustrates our proposals. There are various types of networks and social movements, from those that support of open access to information and knowledge — a deeply rooted principle among networks of library scientists and archivists — to the various groups and movements for free knowledge, which question prevailing intellectual property models in industrial societies (Creative Commons, Copyleft, etc.). Without examining the distinguishing characteristics of

each group, our discussion highlights the significant role they all play in increasing the democratization of knowledge.

Other authors have addressed these matters, such as Harvard professor Yochai Benkler, whose book *The Wealth of Networks* (2006) is in line with several of our proposals. He states that "we are seeing the emergence of a new stage in the information economy, which I call the networked information economy" (2006, p. 3). Quoting von Hippel, Benkler points out that users have created "non-market production" (p. 4) and share its results with each other. Based on the cooperative production of information and knowledge, Benkler calls it "peer production of information, knowledge and culture" (p. 5). Typical examples of this type of horizontal production of information and knowledge are GPU/Linux, Wikipedia, SETI@Home networked computation and many other cases of P2P culture, which share and also generate new knowledge.

The most illustrative and perhaps most radical example is GPU/Linux. The major claim of the community of developers and users of GPU/Linux is "the freedom to improve the programme and publicize others' improvements, so the entire community benefits. An essential prerequisite is access to the source code."[4] Thus, they reaffirm traditional scientific practice. Through specialized journals, following peer assessment, scientific communities publish the knowledge they generate. Afterward, however, scientists freely manipulate the knowledge others have produced through theoretical writings, experimental data or laboratory instruments. In the modern era, the basic tenets of scientific research have included free testing and free interpretation of inherited knowledge. The free software movement continues to fully support these completely democratic principles. In contrast, proprietary software prevents users from freely modifying techno-scientific research instruments, eliminating users as a source of innovation, opting instead for a vertical model of the organization of knowledge. The opposing positions are clearly drawn between those who favour of an aristocracy, or a democracy, of knowledge.

In practice, free software communities are open, as anyone can participate in them actively and store, distribute and use the software according to individual needs and hobbies. However, those communities face difficulties when it comes to socially disseminating their contributions, which makes them liable to the risk of becoming a *new knowledge elite,* separate from the rest of society. Affirming the principle of free knowledge within the fields of production and distribution is not sufficient. The core debate is focused on the *free use of knowledge*. If this principle is adopted, it will have tremendous consequences, which are beyond the scope of this article.

In sum: free software communities are based on the shared democratic use of fundamental knowledge technologies. The values and operating rules applied by network-users and network-companies are influenced by the opposition between free and proprietary software. In the former, democratic values are applied to techno-scientific practice. In the latter, those values apply in the political arena but not to competing techno-scientific companies in the knowledge economy.

Irrespective of the problems and risks they may entail, which do exist, it is clear that this

type of model points toward an open knowledge society, and even toward a democratization of knowledge. That is because, from their inception, the groups and teams are open and they follow the same operating rules based on shared democratic values, summarized as "free open knowledge." The model is not ideal, nor is the scientific practice free of difficulties. However, it is not based not on the privatization of knowledge, but instead, the principle of "shared knowledge", and that is of primordial importance.

Networks of users freely share and generate knowledge. For this reason, they are significant agents in the governance of knowledge societies.

**Notes**

**1** This article was written as part of research project FFI 2008- 03599/FISO, *"Filosofía de las tecnociencias sociales"* (The Philosophy of Social Techno-sciences), financed by the Ministry of Science and Innovation of the Spanish Government.

**2** His work was based on empirical studies in various productive sectors in which, according to entrepreneurs, significant innovations had taken place. Some arose in R+D departments and others did not. Von Hippel provided numerous examples where innovations did not arise from scientific research in R&D departments in companies but instead from suppliers, distributors and users.

**3** Also noteworthy is the *Open Innovation* method proposed by Chesbrough (2003, 2006), which expands on the work of von Hippel and his followers.

**4** See *Conferencia Internacional de Software Libre* (2007), "Universalización del conocimiento" section, p. 24.

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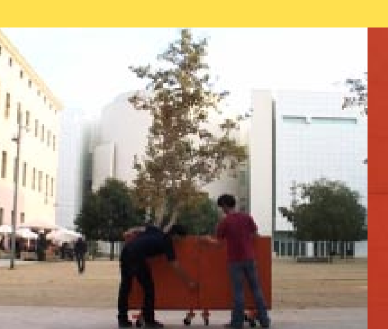
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3D
MOTION
A FAZER CUPCAKES
COZINHAR CARIL
COZINHAR
FOTOGRAFIA
Esgrima
COSTURA (FAZER ROUPA)
DESENHO
PINTURA FACIAL
Cortar o meu próprio Cabelo
ARTE
3D
COMO FAZER CARTEIRAS
Fashion vestir
COSER BOTÕES
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escrita
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ORIGAMI!!
INDESIGN PHOTOSHOP. TRATAR IMAGEM.
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MARKETING SOCIAL
SER FOTOGRAFA PROFISSIONAL
ESCREVER
ENSINAR COMO VENDER UM ESPECTÁCULO
CINEMA
MARKETING E CULTURA
GERIR UM ORÇAMENTO
POESIA
mudar o rumo da vida
XILOL
PERMACULTURA
TELEFONAR GRATUITA
REDES

NOMADISMO
FALAR Alemão
NÃO ROER ÀS UNHAS
ESTAR
SNOWBOARDING
MASSAGENS
BODYBOARD
CARRO S/ GASOLINA
BODYBOARD
CORPO
Dança clássica
Estou mas não estou! Já fui! Mas não vou.
fazer monoski
MAQUILHAR
COMO GANHAR DINHEIRO SEM TRABALHAR
COMO CAIR SEM MAGOAR
EXPRESSÃO DRAMÁTICA
EXAMES RESPIRATÓRIOS
como criar mnemónicas ?
MERGULHAR
CORRER EM círculos de costas
TÉCNICA / JOGAR BASKET
ECOLOGIA
EXPRESSÃO
VOAR
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PROVAS DE ESFORÇO (CARDIOLOGIA)
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CONVIVER
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PLATONIQ
***Bank of Common Knowledge (BCC)***, 2006-2009

It is logical to think that the so-called Information and Knowledge Society we find ourselves in today assigns special value to information and knowledge, understood now as the agents driving the current social, political, economic and cultural transformation. However, it is certainly not as logical to think that the strategic position knowledge occupies in this contemporary development and transformation should be based solely on the privatization of a common good as valuable as knowledge.
All difficulties in mobility and accessibility to information and knowledge also pose a serious obstacle to the development of the Knowledge Society. Consequently, creating, sharing,



Shared knowledge
is more power



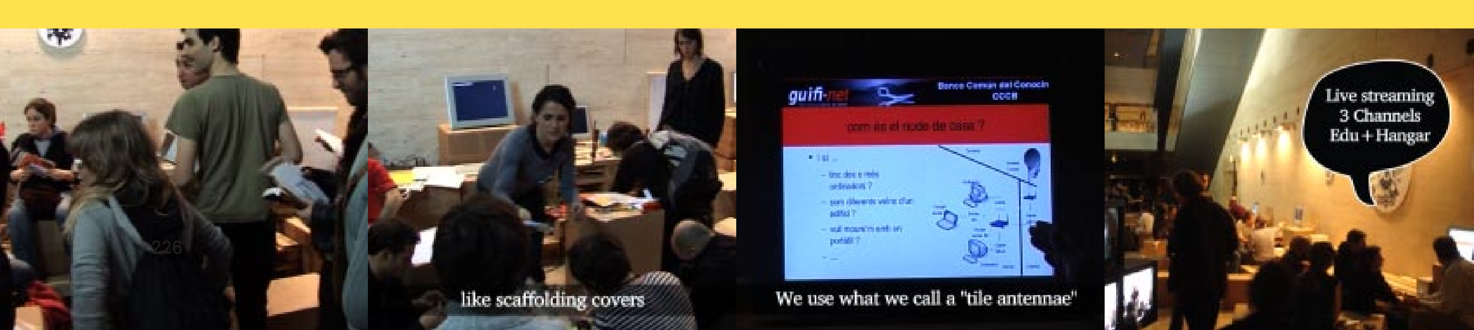


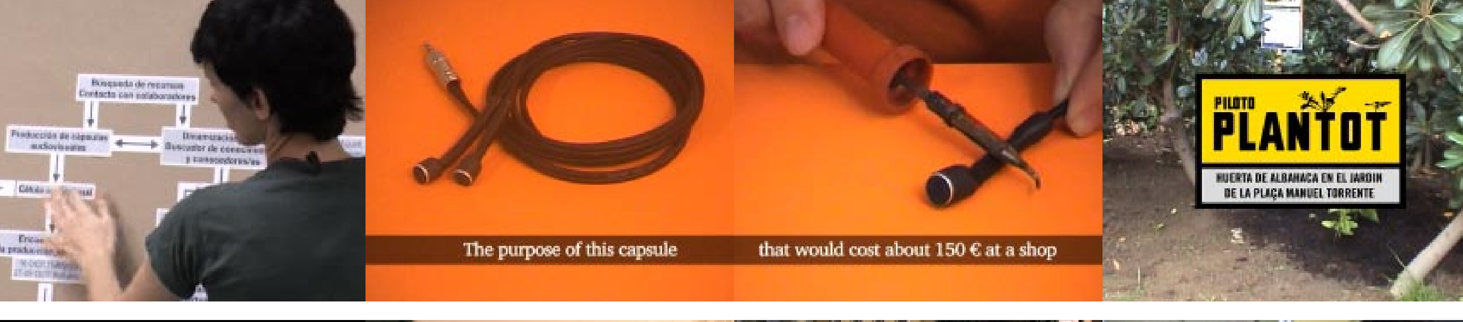

transmitting and extending the exchange of knowledge in the public sphere become an essential activity if we also aim to contribute to the growth and development of our societies. Everyone knows that the development of the Internet was possible thanks to the collective effort and work of thousands of distributed agents who publicly shared their knowledge to achieve a common goal. Collective creation and intelligence have been fruitful in the context of information and communication technologies, and the participatory, cooperative and collaborative dynamics practiced by the community of programmers and Internet users in the last few decades led to a body of theoretical and practical approaches which have come to comprise what is known as Free Culture. Examples of the new forms of production and distribution behind the






name "Free Culture" and the Copyleft philosophy include the Internet with its information exchange protocols, P2P computer distribution networks, and free software developed collaboratively under general public license (GPL). The *Bank of Common Knowledge* exports these characteristic dynamics of Free Culture and the Copyleft philosophy to general processes of knowledge generation and transmission among citizens. This way, work processes and methodologies are researched while the production of content, mutual education and citizen participation are carried out for the purpose of giving free access to the knowledge generated by the communities in which the *Bank of Common Knowledge* is installed. Consequently, the contents generated are Copyleft, and can be copied, redistributed or modified freely. Based









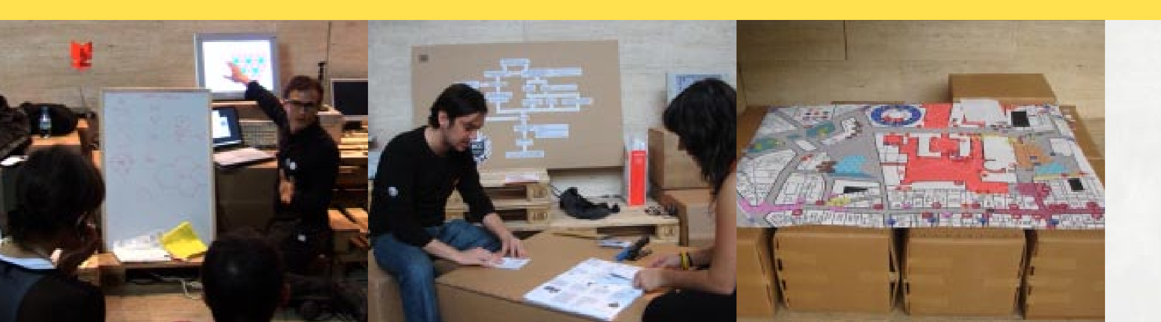




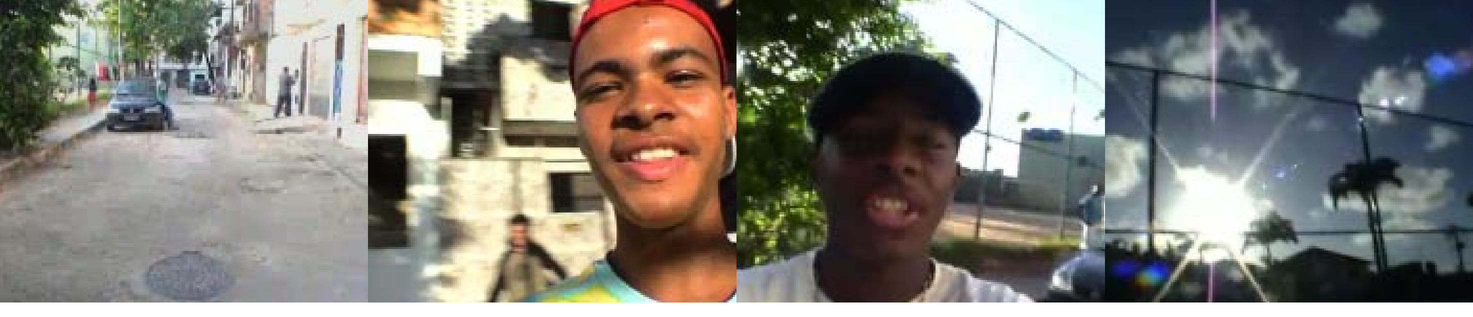


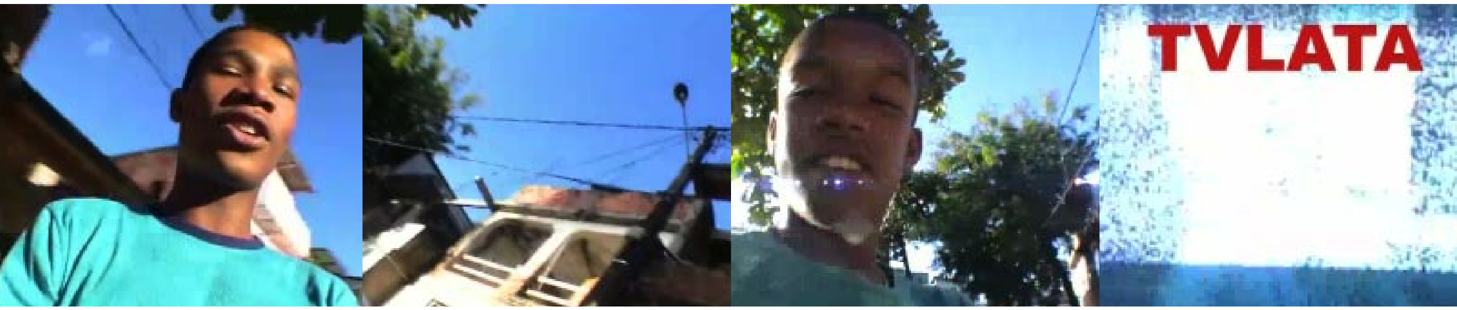

on the organization of meetings among citizens, through an ample typology of resources, formats and dynamics exported from different contexts, the *Bank of Common Knowledge* experiments with new forms of production, learning and citizen participation.

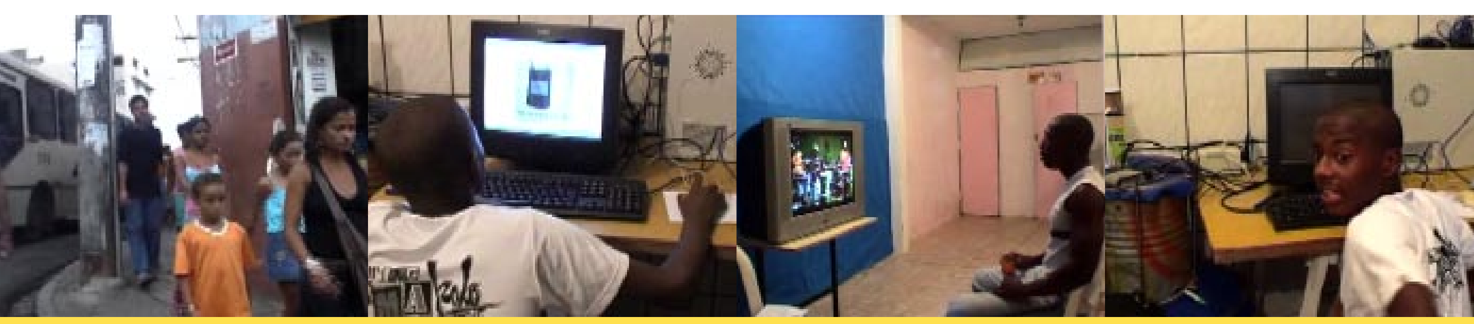
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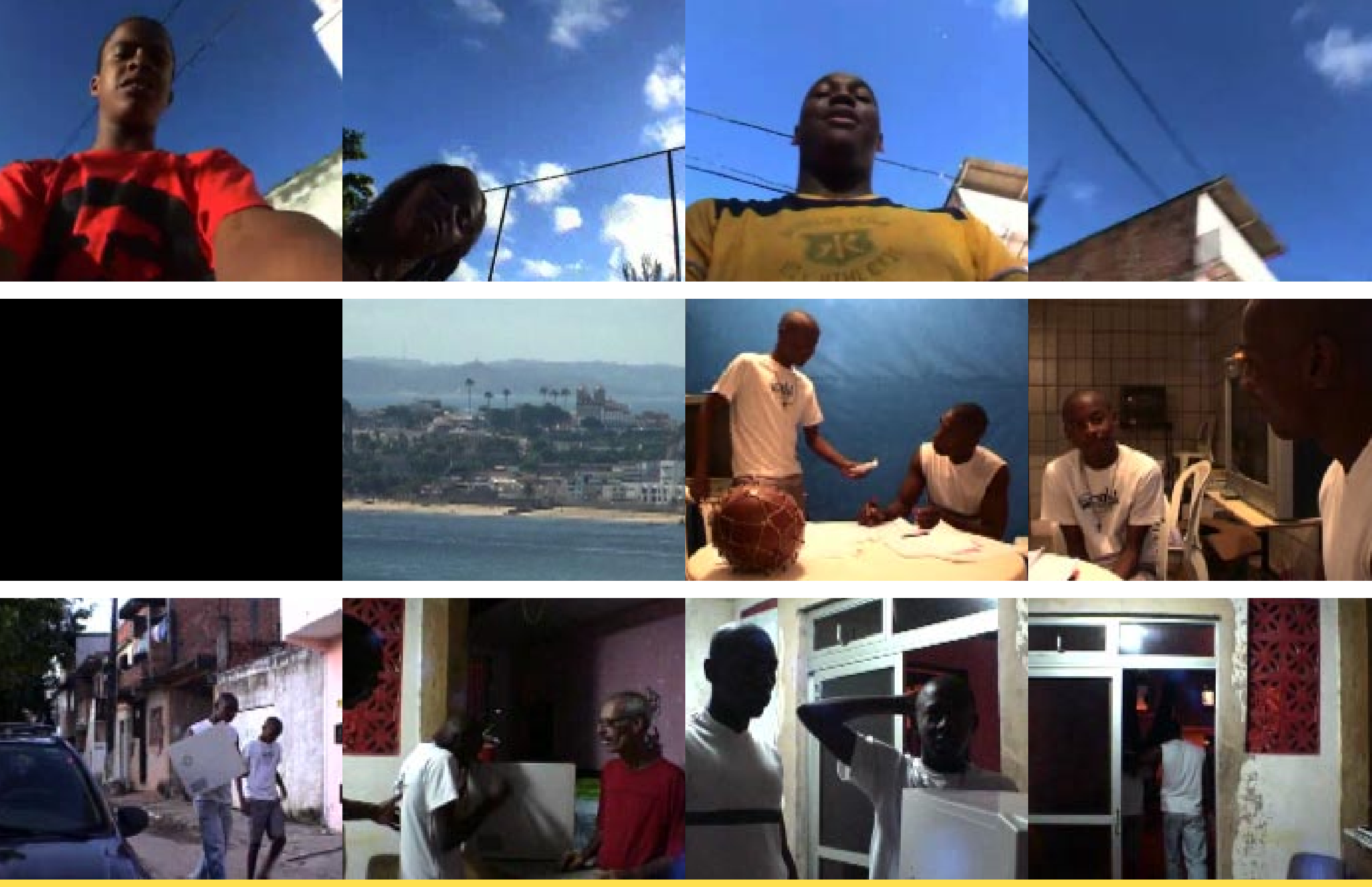




NEOKINOK TV
***TVLATA***, 2007

*TVLATA* is an experimental educational television project carried out by young men and women in the Alagados neighbourhood of Salvador de Bahía, Brazil.
The project began based on workshops organized and produced by the Spanish International Cooperation Agency for Development (<http://www.aecid.es>), carried out with the Grupo Cultural Bagunçaço (http://www.bagunsite.org.br) in Salvador de Bahía. Neokinok.tv (<http://www.neokinok.tv>) was asked to run one of the workshops, and they proposed educational content related to experimental television, bringing together a series of arts (music, theatre, etc.) and technologies (information science, electronics, etc.). The project was called *TVLATA* and took place during May, June and December 2007. The project was well-received by participants and the entire community and continues growing. At present, a second part is being prepared to be held in 2008.
From the start, the idea was to build a communication laboratory based on audiovisual creation proposals and tools. The young men and women who participated in the activities of Bagunçaço produced works such as texts, images, music and films with the knowledge they were acquiring. This project can be seen on the Internet, at <http://www.tvlata.org>, a dynamic web site where various types of files can be published.
The web site has over seventy videos of various lengths, made by the participants, with subject



matter related to their local culture and their lives in the area, as well as education, fiction, etc. The main office of Bagunçaço is located in the Os Alagados (*The Drowned Ones*) community. The neighbourhood owes its name to the fact that it is built on land won from the sea, originally with *palafitos*, houses built on wooden stilts with tin walls over the still waters of the bay. The area has continued to grow to house over one hundred thousand residents, which makes it one of the largest *favelas,* or shanty towns, in Salvador. Until now, this area was portrayed on conventional television only in terms of its violence and poverty. With *TVLATA*, their own communication media, the youth of Alagados show another side of the community and talk about their everyday lives and their values from a different perspective, strengthening their identity and self esteem, expressing reality as they see it, with different audiovisual creation lines, novels, historical images, etc. Os Alagados is a community poor in economic resources but rich in culture, with plenty of creative motivation. Other specific objectives of the project are to: offer digital literacy and audiovisual training for youths and teenagers, contributeto the social cohesion of the youth of the area through strengthening their cultural identity, bring education and culture closer together, enhance the leading role of civil society, stimulate creativity, and open public spaces.

**N.TV.**


SURFING





PEDRO ORTUÑO
***White on Black***, 2004

Looking as a political exercise is what Pedro Ortuño has done in his works, thus exemplifying with great precision what Nicolas Bourriaud has termed "relational aesthetics". Under the media's prophylactic view on reality, an entire structure of paradoxes and dysfunctional matters are hidden, which seem to emerge only occasionally through certain interstices or communicational gaps. In contrast to today's explosion of the documentary as a show and the sumum of all that is spectacular, which turns life into a super-production in high definition and no more than a performance, Ortuño works with eminently real material. Transparency, speed, change and individualism seem to emerge as the defining signs of a globalized society in the hands of post-industrial capitalism. A state of things that forms a subtle ideology assumed as natural, a given, irrefutable because it is invisible. This same imperceptibility of the ideological mechanisms that sustain the "network society" makes critical voices cause a certain cognitive dissonance. And an awkwardness.

Indeed, if there is one item that defines the pattern of globalized society, it is the acceptance of individualism as ideology. Employment issues no longer seem to be analyzed in structural terms but rather on an individual basis. It is no longer the system, for instance, that does not provide jobs; it is the person who is not employable, promotable, functional. Manageable.



Included. This transition toward de-politicizing reality (while reality is made aesthetic at the hands of MTV, the fashion system and love of technology in their ecstasy of constant renewal), is fed by a series of conceptual landscapes and (aesthetic) visions of things. *Technoscapes*, *mediascapes*, *ideoscapes* and *financescapes* portray a planetary view on life that is efficient and aesthetically digestible. A sole poetic and visual global landscape.

*Blanca sobre negra* (*White on Black*) focuses on those sectors that this fantastic operation to poeticize the world has not managed to seduce. Although they form part of the global economic system, given their placement in the network, they are not able to enjoy their status as producer. Like the women of *Blanca*, their physical space is increasingly being restricted, in contrast to those for whom space has already lost its restrictive character. For these sectors, time has turned into something that is oppressive, super-abundant and superficial, where nothing ever happens, in contrast to those where time on-line and on time is a scarce commodity. This set of contradictions forces us to reconsider whether this network pattern (a sole network) is indeed the one that orders the global production system. Asymmetry and notions of "centre" and "periphery" are incompatible with its distributive nature, and therefore, perhaps the time has come to accept the existence of different networks that are dependent, subordinate, and as a result, inevitably, dysfunctional.

**A.S.P.**



ANTONI ABAD
***Canal* MOTOBOY***, 2007-2008
***Canal*ACCESSIBLE***, 2006
***GENEVE*ACCESSIBLE***, 2008

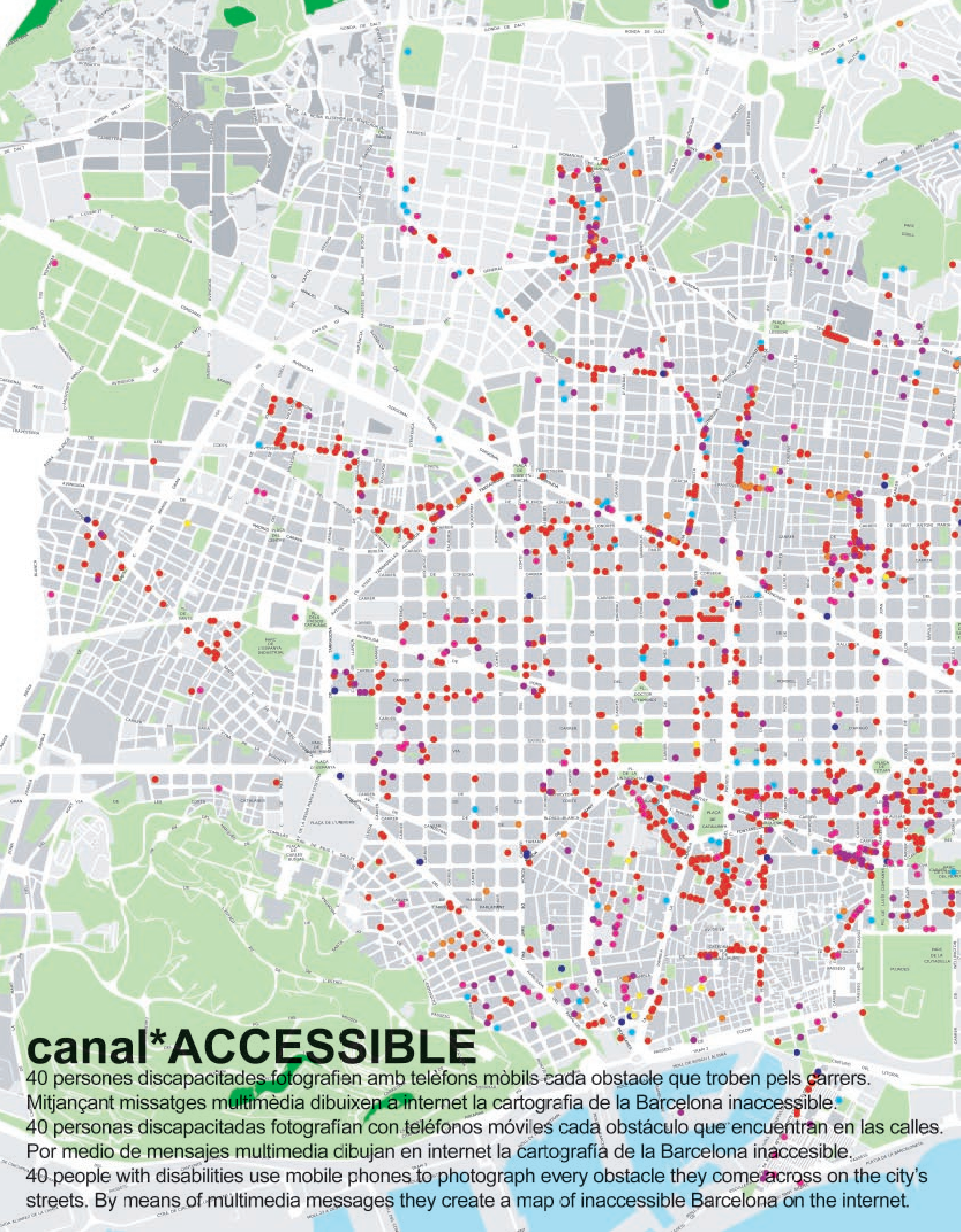
We agree with Hal Foster who defines culture as an arena from which it is possible to answer, and of course, when he states that we are in a system so de-structured that it is very hard to construct a minimally majority democratic response in it.[1] However, we do not agree with him when he speaks of that response as something that must happen “within established codes.”
For perhaps the artist, as a social, political and democratic subject, has the capacity to do more than respond to certain specific problems. Perhaps the artist can produce something that is not simply a political response, an analysis or a brainy deconstruction. Perhaps art is capable of producing public space, public sphere, and therefore, democratically political. For the public sphere is a political product that is fundamental in terms of the community, that is, of what I have or do not have in common with other persons, of the common ground we share.
Participation in this sense is important given that it is important to taken on the production of meanings from a consensus with different communities. “Separation” does not seem to be an acceptable or democratic artistic position when we speak of the things we have in common.
Antoni Abad in <http://www.zexe.net> offers a project that, since 2003, has been based on the creation of digital communities (the most public,

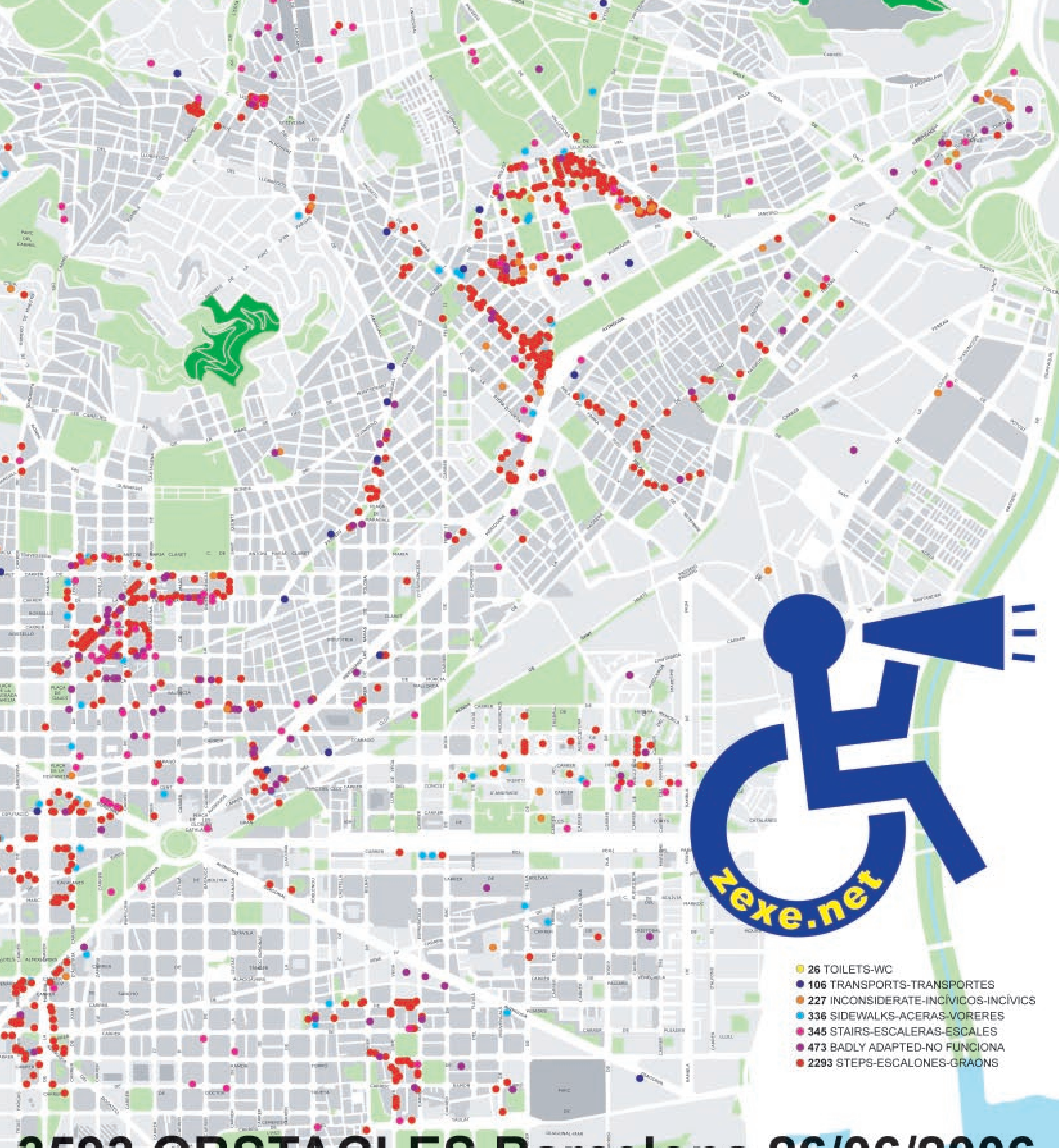


accessible place we have as citizens of Western democracies, now that we have practically lost the streets) using the photos that individuals from these groups take with their mobile phones. These are groups with no public visibility, with almost no representation. In *Canal*ACCESSIBLE*, physically disabled persons in Barcelona and Geneva photograph obstacles in the city, used to generate a map of a city that is inaccessible to their community. In *Canal*MOTOBOY*, motorcyclists in Sao Paulo become the reporters on experiences and environments in their city. However, Abad's aim is not only to provide certain individuals and communities with methods and tools that enable them to "become visible", which is the goal of some activist groups. He also intends to generate a new form of collective knowledge on the Internet that includes taking a new look at these communities, of course, but mainly aims to look again, to "re-view" our cities from others' points of view. From this new public sphere, others' eyes force us to take a new look.

**Y.A.**

1 FOSTER, H., *Recodificaciones: hacia una noción de lo político en el arte contemporáneo*, in Blanco, C., Claramonte, E., *Modos de hacer. Arte crítico, esfera pública y acción directa*, Universidad de Salamanca, Salamanca, 2001, p. 229.


canal*ACCESSIBLE
40 persones discapacitades fotografien amb telèfons mòbils cada obstacle que troben pels carrers.
Mitjançant missatges multimèdia dibuixen a internet la cartografia de la Barcelona inaccessible.
40 personas discapacitadas fotografían con teléfonos móviles cada obstáculo que encuentran en las calles.
Por medio de mensajes multimedia dibujan en internet la cartografía de la Barcelona inaccesible.
40 people with disabilities use mobile phones to photograph every obstacle they come across on the city's streets. By means of multimedia messages they create a map of inaccessible Barcelona on the internet.




# 3593 OBSTACLES Barcelona 26/06/2006

**people** Inigo Alvarez, Josep Xarau, Salvador Pi, Merce Campeny, David Rodriguez, Joan Basums, Carlos Vidal, Joan Prat, Oscar Rodriguez, Javier Touzon, José Conrado, Lucia Tevar, Rosa Bonastre, Marta Boltó, Josep Gallart, Martin Leates, Jordi Pie, Oriol Bono, Eugeni Boix, Jesus Gonzalez, Mireia Garcia, To Monreal, Joaquín Esteban, Maria Rosa Pane, Antonio Ortega, Teresa Nisarre, Khalid Zerguini, Nicolas Basadonna, Juan Canton, Craig Grimes, Mar González, Francisco Nieto, Antonio Vargas, Miguel Angel, Sonia Guerrero, Holger Strauss
**whith the help of** Servei de Cartografia de l'Ajuntament de Barcelona, Departaments de Cultura i Benestar Social, Generalitat de Catalunya **sponsored by** Amena, Nokia **production** Centre d'Art Santa Mònica
**crew** Iban Calzada, Pilar Cruz **coordination** Mery Cuesta **programmer** Eugenio Tisselli **project** Antoni Abad

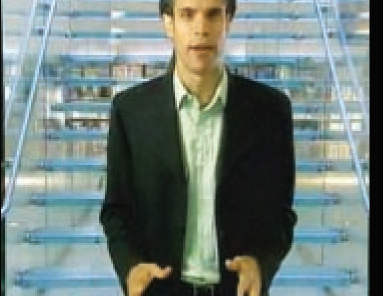



DANIEL GARCÍA ANDÚJAR
***X-Devian. The New Technologies to the People System***, 2003

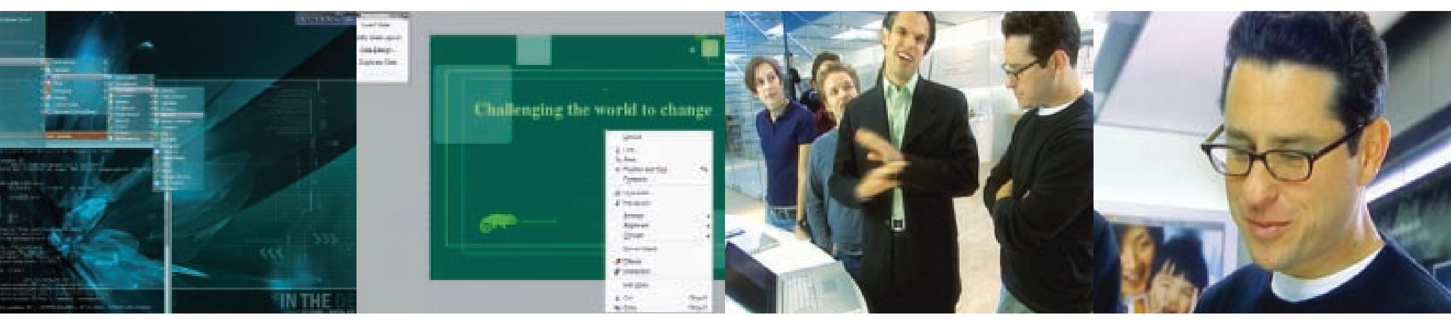
Although the use of free and open source software is becoming more widespread among non-specialist users all over the world, its potential to contribute to changes in culture outside the computer context is still in the early stages of development. The project *X-Devian. The New Technologies to the People System* by Daniel García Andújar is one of the most elaborate examples within contemporary art of how that potential could be explored and used in a critical and imaginative way. The project revolves around the operating system, *X-Devian*, a 'redesigned' version of a current Linux distribution. Through its multi-level installation format involving videos, objects, the website, computer hardware, manuals, imagery, 'code graffiti', information, abstraction and fiction, the project presents free and open source software as a cultural discourse, rather than just a technical language. The point being that that discourse needs development, just as much as the software itself. The installation functions as a both conceptual and practical interface to free and open source software encouraging engagement through the understanding of culture as a matter of doing things together for the common non-proprietary good. It removes free and open source software from the ghetto of programming code and connects it to a network of assemblages of human reflection, expression and ability.



x-devian
by knoppix



With over 150
innovative new feautures,
it's like having an
all-new computer




Linux and Windows



Thereby, *X-Devian* turns free and open source software into a progressive tool to reprogram the use and understanding of computers as well as social culture at large.

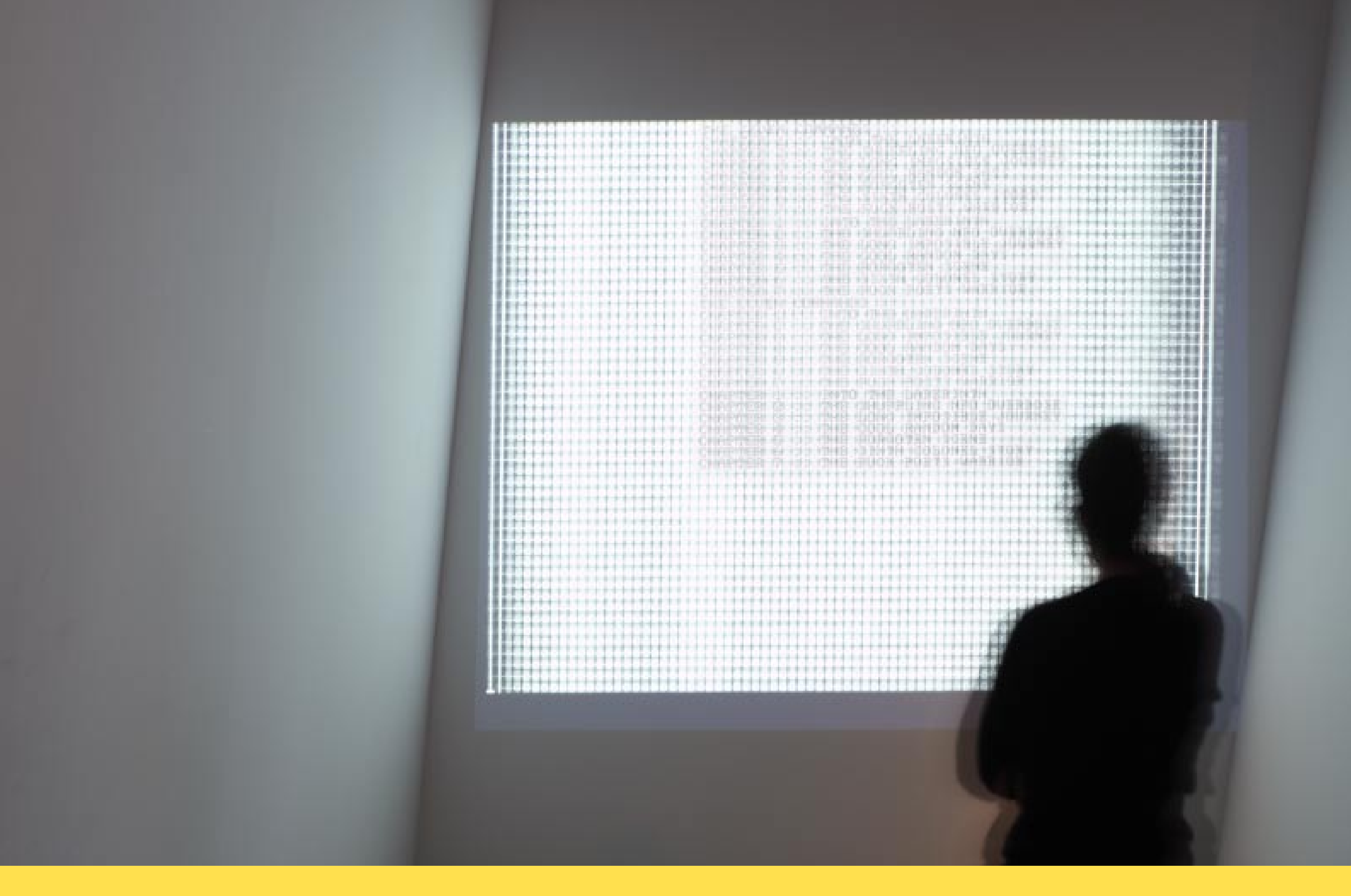
In terms of art history, *X-Devian* is related to the tradition of conceptual art and its interest in the aesthetics of political discourse, while mixing in the appropriation tactics of pop art and the virtualities of net art to allow for all sort of ironies and complexities. Thus the project eloquently demonstrates that contemporary art's engagement with issues of technology need not result in computer formalism or fetishism. On the contrary, seen as a radical cultural programme, technology, and in particular free and open source software, can contribute to the development of contemporary art's general involvement with issues of social relations and of cultural production run by algorithms of generosity and participation rather than by the omnipresent logic of property. Few artists are able to realise this potential with as much conviction and promise as Daniel García Andújar.

**J.Lll.**

*Technology is a Hun*




man Right



JOAN LEANDRE
***NostalG2 // L'AGE D'OR NFO.EXE***, 2003-2008

To Brute Force and Prefect Fatal Error. Perhaps savage times are over, and now we live in an era when excesses are condoned, and although it might seem a mere illusion in the days of permanent updating, the borders of legality are fading. I thought of that one of the cold nights in 1999 at SPMB37, a night spent scanning IPs and consulting NFO files, when beyond the bare word or geometric thought (which at times becomes fascinated by fetishism), experience is what counts and overcoming widespread paranoia: "I found myself trying to tame the Downloading Machine, the traffic upstream and downstream was heavy for the first two hours until about three o'clock in the morning, my P2P server collapsed with a multicolour roar. It was the Age of Excess and Avalanche... millions of

: REPTILES HOLE #3 :+46-28-PRIVATE
: REPULSE :+46-270-121-38
: SANCTUARY :+46-319-185-87
: SECRET GATE #1 :+46-418-196-66
: SECRET GATE #2 :+46-418-269-00
: SERIAL ACCESS :+46-140-502-68

| | |
|---|---|
| FPS | File Propulsion System |
| BAD | Bitchin' Ansi Design |
| TRA | The Rebel Alliance |
| PST | Parasite |
| IND | Independence |
| DDM | The Doomsday Machines |
| WAC | Wild Ansi Creators |
| STC | SaTanic Couriers |
| NCC | Norwegian Cracking Company |
| GEM | Gemini |
| BMF | Bad Mother Fuckers |
| TUN | The Underground Network |
| PWS | Piretes who canot spel corriers |
| iTU | Infinity Traders Unlimited |
| REM | Radical Elite Movement |
| LAME | Lunatics And Maniacs Encorporated |
| DS | 2) Dream Syndicate |
| AAFH | ANSI Artists From Hell |
| TDK | The Destiny Knights |
| ODA | Over-Dosed Anarchists |
| HBD | Hybrid |
| CF | Cyber Force |
| UCF | 2) United Cracking Force |
| RLT | Reality |
| LoD | Legion of Doom |
| EPiC | 1) Excellence Produced in Creativity |
| AD | Altered Destiny |
| THG | The Humble Guys |
| PAM | Pathetic ANSI Makers |
| HSGMT | High-Speed Global Mass Trading |
| CNRI | Corporation for National Research Initiatives |
| UGC | UnderGround Council |

packages in tiny fragments, moving at cruising speed towards thousands of remote destinations, between nostalgia for the good old days and the euphoric promise of constant renovation: the great bastard in the shadows promises immortality, with each new piece of serialized hardware and software, it offers eternity… I continued to spin constantly." Prefect Fatal Error in Permanent Updating speaks of innocence without conditions, of the origins fascinated by the unknown but guaranteed path. Thus, the line of separation is drawn, which marks the limits between convention and the unnameable. If one wants a definite answer or the speech of the century it will no longer depend on factors under our control; instead, it will be a question of luck and pleasure in the pure void of the automatic terminal. The Downloading Machine is out of control. Among sectors and cylinders, there lie data which should be irremediably forgotten forever… or did anyone

| | |
|---|---|
| GODSEND | CROCODILE |
| EQUINOX | THE SILENCER |
| FAIRLIGHT | SANDMAN |
| INDEPENDENT | ZYNC |
| INDEPENDENT | ZYNC |
| IGNOMINY | EAGLEMAN |

| | |
|---|---|
| SERPENT HILL #2 | +46-826-919-2 |
| SHADOW PASSAGE | +46-331-412-92 |
| SHADOW ZONE | +46-876-514-55 |
| SIROCCO STATION | +46-451-158-58 |
| SLAMMER,THE | +46-862-301-96 |
| SOMEWHERE IN TIME | +46-404-230-39 |
| SOMEWHERE IN TIME | +46-404-230-86 |
| SOUTH END,THE #1 | +46-410-198-17 |
| SOUTH END,THE #2 | +46-410-198-18 |
| SPEED HUNTERS | +46-174-341-11 |
| STAGE DIVE | +46-161-280-47 |
| STATE 69 | +46-331-056-15 |
| STREETS OF FIRE #1 | +46-855-010-498 |
| STREETS OF FIRE #2 | +46-855-010-490 |
| STREETS OF FIRE #3 | +46-855-0EL-ITE |
| SYNTHETIC CYSTIMES | +46-392-220-84 |

really mean to leave signs of their trail? "I live at the limit, looking at the abyss of the pulsing cursor, immobile as I wait for the final denouement. On that evening, the centre will no longer be found in what is proper and permitted, on the edges; it will be located instead in a past present on the dark face of the monument." "...[To] Brute Force, thank you for mapping the darkest places on the web, to Final Bastard for leading us toward the narrow tunnel that runs along nameless paths toward wide open doors (...). The Golden Age is now and always, my dream is to embrace Nanga Parbat."[1]

**J.L.**

**1** K.K: "La actualización permanente" (Permanent Updating).

| | |
|---|---|
| TRADE ZONE,THE | +46-498-241-602 |
| TRANCE LAND | +46-262-756-66 |
| TRANCENTRAL | +46-315-855-60 |
| TRENCH | +46-827-304-6 |
| 5330 TRESPASS | +46-859-089-944 |

| | |
|---|---|
| DUPLO | EZCO |
| DUPLO | EZCO |
| CYCLONS | BOZ |
| INDEPENDENT | BOOZER |
| IRIS | SPONY |
| HONEY | DISTLER |
| THE SILENTS | ICE |
| THE SILENTS | ICE |
| INDEPENDENT | RAINMAN |
| INDEPENDENT | RAINMAN |
| WEIRD DESIGN | DEADLY ANGEL |
| OBSCENE | NURGLE |
| DEADLINE DESIGN | AXY |
| QUARTEX | MOGWAI & MINIST |
| QUARTEX | MOGWAI & MINIST |
| QUARTEX | MOGWAI & MINIST |
| INDEPENDENT | RABZI |
| LIMITED EDITION | VILEUS |
| LIMITED EDITION | VILEUS |
| DEFIANCE | MIKE |
| AFL/COMAKIDS | DEXTER |
| INDEPENDENT | ZCANDALER |
| EQUINOX | RIOTER |
| IMAGINE | MEGABYTE |
| UNKNOWN | UNKNOWN |
| HARDCORE DESIGN | RAJ-BAN |
| HARDCORE DESIGN | RAJ-BAN |
| THERAPY/INFECT | MACROMAN |
| THERAPY/INFECT | MACROMAN |
| FATAL UNITY | BOHEMIAN |
| TENSION | ANGEST |
| FAIRLIGHT | REBEL |
| HUMANE | INFINITY |
| FREEZERS | REVEREND D |



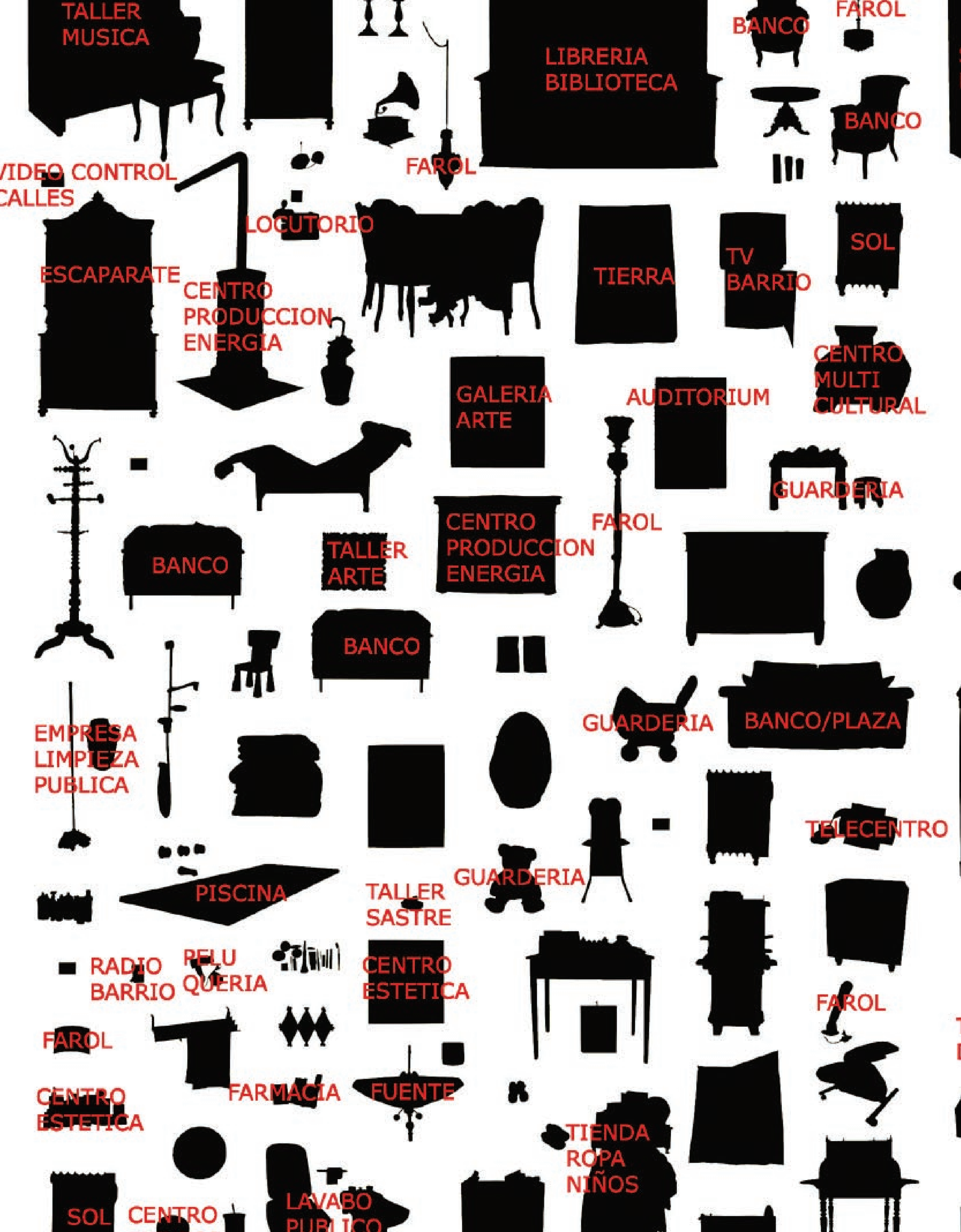

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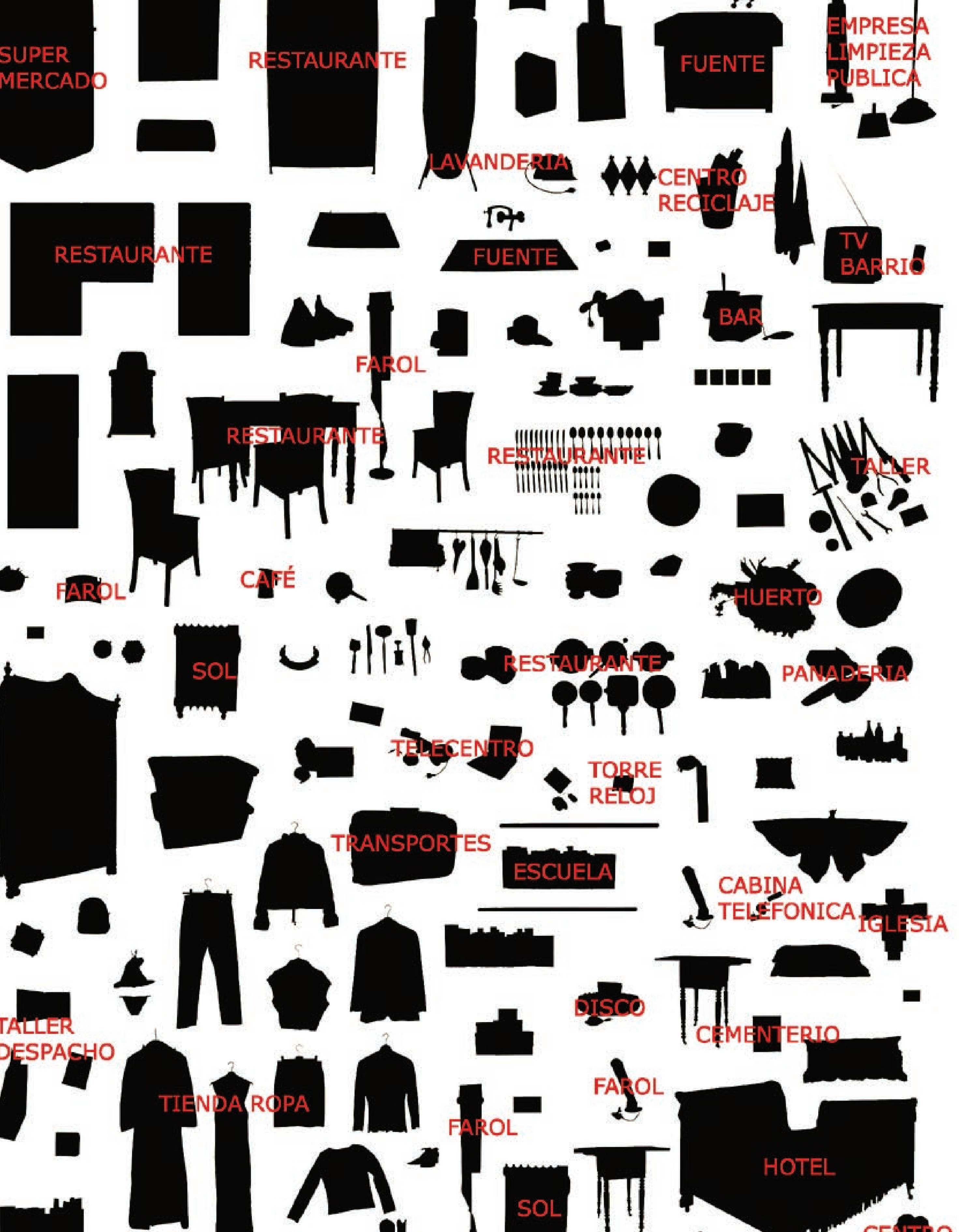
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SYSTeM(s)       :
NUM. OF DiSKS   : xx HD
RELEASE DATE    : MM/DD/1997
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BIIiiiIIG FOk tO ALL LAmerz ..!

***Global capitalism is increasingly becoming a network favouring the productive capture of social creativity. The network is the form of hegemonic organization, not only for social movements but also for the production cycle of merchandise, languages, symbols, relations and so on, that is, for the production of reality.***

**Margarita Padilla**


TALLER
MUSICA
BANCO
FAROL
LIBRERIA
BIBLIOTECA
BANCO
VIDEO CONTROL
CALLES
FAROL
LOCUTORIO
SOL
ESCAPARATE
TIERRA
TV
BARRIO
CENTRO
PRODUCCION
ENERGIA
CENTRO
MULTI
CULTURAL
GALERIA
ARTE
AUDITORIUM
GUARDERIA
CENTRO
PRODUCCION
ENERGIA
FAROL
BANCO
TALLER
ARTE
BANCO
GUARDERIA
BANCO/PLAZA
EMPRESA
LIMPIEZA
PUBLICA
TELECENTRO
GUARDERIA
PISCINA
TALLER
SASTRE
RADIO
BARRIO
PELU
QUERIA
CENTRO
ESTETICA
FAROL
FAROL
CENTRO
ESTETICA
FARMACIA
FUENTE
TIENDA
ROPA
NIÑOS
SOL
CENTRO
LAVABO



SUPER MERCADO
RESTAURANTE
FUENTE
EMPRESA LIMPIEZA PUBLICA
LAVANDERIA
CENTRO RECICLAJE
RESTAURANTE
FUENTE
TV BARRIO
BAR
FAROL
RESTAURANTE
RESTAURANTE
TALLER
FAROL
CAFÉ
HUERTO
SOL
RESTAURANTE
PANADERIA
TELECENTRO
TORRE RELOJ
TRANSPORTES
ESCUELA
CABINA TELEFONICA
IGLESIA
DISCO
TALLER DESPACHO
CEMENTERIO
FAROL
TIENDA ROPA
FAROL
HOTEL
SOL



## Sociopolis

Vicente Guallart

**Creating buildings that generate 100% of the energy they consume is beginning to be seen as realistic. In fifteen years, it will certainly be an accepted part of normal reality. At the Institut d'Arquitectura Avançada de Catalunya *(Institute of Advanced Architecture)*, we have attempted to understand all the functions a city might perform and how they can actually be developed on all scales: the concept of multi-scale architecture begins with a room and encompasses everything in the end. This is taking place in urban and even in economic circles. It is essential to create structures to manage networks. Ensuring solid structures is even more important than the content.**

**We are talking about a functional structure. Our aim is to work in a network. It can be compared to an information technology system. There is a zero node, which is a computer, a wire connecting it and an environment where all of this takes place. We are in favour of a techno-agrarian society. Going back to the land, being able to live at a very slow pace and at the same time, work with any place in the world via videoconferencing. A high-tech society has meaning only if we go back to the land. When a city cannot incorporate better living conditions or the best innovations on a functional level, it starts to decay. Cities should know how to transform themselves, growing both upwards and downwards.**

**In *Sociopolis* we are going to make a web site for the neighbourhood that aims to self-organize certain social relations that could be formed in the ordinary way. Putting information into the system lets you know which older person in the neighbour-**

hood can care for your child, which children play the same sport, who has the book you want to read and will lend it to you, who can lend you a saw if you haven't got one... All of this generates sociability.

The Institut d'Arquitectura Avançada de Catalunya in Barcelona is an example of a group of persons with a common purpose. It used to be that whoever had secret information was the richest. We, however, intend to generate wealth by providing information. Instead of presenting the way we imagine the world, we have created a platform for people to tell us how they imagine it.

Pp. 248, 249. Laura Cantarella, *City House.*

Pp. 250, 253. Laura Cantarella, *Inhabit X-ray.*



# Networks of urban sustainability: towards a model of a knowledge city

Salvador Rueda

There are many teams and many institutions working on the conceptualization of new urban developments, and the remodelling of existing ones as well, with criteria of sustainability. The following reflection analyzes, in part, of one of the axes of the urban model extracted from the concept of a rethought-out Mediterranean city, which could bring us closer to resolving the great challenges we face today as a society.

## The sustainability equation

To maintain their organization, urban systems require the entry of materials and energy (natural resources) that are obtained from the exploitation of other systems in nature.

The exploitation of ecosystems means their simplification; their capacity to maintain more elevated stages of succession is diminished. According to Margalef's principle, more complex systems gain information from more simplified ones, similar to the way electrons move between

opposite poles. The capacity of control that urban systems have over certain flows of material, energy and information on any part of the planet enables them to maintain their organization at the expense of the exploitation of other ecosystems, which become simplified. As a consequence, at times, the human groups which have been exploiting those resources throughout the ages find themselves deprived of basic resources, and are forced to move to other places, becoming environmental refugees.

The flows of natural resources — materials and energy — circulate from any part of the world to urban systems and their organizational models of territory, mobility, waste, water management, etc. The increase or decrease in the exploitation of resources over time depends on urban organizational models. Thus, for example, if the inhabitants of a city agreed to reduce the number of vehicles on the road by 30% — that is, if they decided to change their model of mobility and succeeded in doing so — they would reduce energy consumption for mobility by the percentage of vehicles no longer circulating.

The flows, however, do not go in a single direction, that is to say, from exploited systems to the city. Rather, once materials and energy have entered urban organizational models, they exit in the form of polluting waste, which impacts the systems supporting us. This implies their simplification, in addition to the simplification caused by exploitation. In the previous example, the reduction of the number of vehicles on the road and the subsequent decline in energy consumption implies a decrease in polluting gases, globally (e.g., $CO_2$, CO) as well as locally and regionally (COV, $NO_x$, $SO_2$, particles, etc.).

The pressure on support systems, whether from exploitation or the impact of pollution, depends on how cities are organized. In the example, mobility was discussed, but it could be extended to any area of urban management: urban planning, water, waste, etc. Clearly, whether pressure on the environment is greater or lesser depends on us, on how we organise our urban systems.

Reducing pressure on support systems is the path to increasing our pre-emptive capability, diminished now by the continual increase of uncertainties generated by moving towards non-sustainability. In fact, non-sustainability rests on two key factors: one refers to pressure on support systems and the other to urban organization. Pressure from the aforementioned exploitation or impact of pollution is growing explosively today due to the logic inherent in the current model of making cities. They are types of logic that, instead of reducing pressure on support systems, increase it, for this economic and power logic is based on resource consumption as a competitive strategy. Macroeconomic indicators such as GDP and its continuous growth are proof. GDP, as we know, bases part of its growth on the consumption of resources and it is an indicator that signals the path to economic growth, which is currently confused with development.

From that perspective, talking about "sustainable development" today is a contradiction, given that development means an ever-growing increase in pressure on the support systems whereas sustainability is the contrary. With the present strategy for competition based on resource consumption, "development" and "sustainable" are a contradiction in terms, an oxymoron. The only possibility to bring them together would have to come about through a change in competitive strategy, a strategy based

on the increase of information to replace the present strategy, which is based on resource consumption.

The information organized in urban systems constitutes the second axis on which the process toward sustainability can be built. The processes of biological systems in nature — evolution of species and succession of ecosystems — show us how simple structures change to complex ones. In the case of evolution, for example, primogenital molecules are followed by more complex organisms, such as individuals of the human species. This process towards complexity occurs, however, by maximising entropy in terms of information, by increasing the efficiency of the process. Humans, the most complex organism we know, have energy power of between 120 W and 150 W, that is, the power of a domestic light bulb, and with that, a person moves, works, studies, makes love, and so on.

This process towards efficiency is not the option chosen today to build cities, for, although organized information increases (in complexity), it does so at the cost of squandering resources, in accordance with the current strategy to compete. For each unit of energy employed, increased or maintained urban complexity is effectively reduced, since, as stated, the logic of efficiency is not the logic being applied.

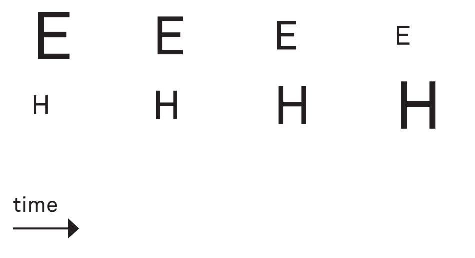
Reducing pressure on support systems and increasing urban complexity are parts of the same equation if we want to move towards "sustainability." It can be expressed as the quotient of E/H, where E is the energy (resource consumption) the system needs to maintain H, urban complexity.

E/H is the expression of urban efficiency and it becomes the guiding function for sustainability. Its evolution over time highlights the two aspects linked to it: resource consumption, with the subsequent simplification of supporting ecosystems and urban organization.




The current model for producing cities and its accompanying models (mobility, waste, etc.) highlight the process towards growing inefficiency. Resource consumption increases over time whereas the urban organization it supports does not increase significantly. This process is the opposite of nature, which maximizes entropy in terms of information, or in other words, gains a greater lever of organization for the same energy input.

The model of a sustainable city would be one which, inverting the present trend, gradually reduces energy (resource consumption) while it increases the value of urban organization.




The decrease in the equation over time becomes the guiding function of cities' process toward sustainability. For urban systems, that translates into the maximization of information entropy.

## The sustainable city and the knowledge city: tackling the challenges of today's society

The guiding function E/H also provides us with a complementary reading that links to urban models. In fact, the values of E are related to resource consumption, with E its synthetic expression, accepting that energy runs through everything. Urban commitment, in the form of plans and strategies (such as Spain's *Agendas 21*) to reduce resource consumption have a direct bearing on the pressure on terrestrial ecosystems and on the central axis of sustainability, and thus on the creation of the most sustainable urban models.

The sustainable city (or rather, more sustainable or that is organized with criteria of sustainability) shapes its organization with the goal of increasing our ability to foresee a future that is uncertain due to urban pressure on the Earth's systems. Reducing E, that is, reducing resource consumption, has to do, above all, with models of land occupation, urban planning, urban mobility, architecture and metabolism. In addition, lifestyles, in one way or another, reflect the preceding models.

As mentioned above, reducing resource consumption goes against the current competitive strategy between territories, based on the exact opposite, on increasing natural resource consumption. Changing strategy would involve a Copernican change in the present economic logic and with that, of lifestyles based on mass acquisition of consumer goods, land occupation, water and energy consumption. Changing strategy entails, in current conditions, a true revolution that seems impossible to tackle if steps are not taken towards an option which combines and makes compatible development and sustainability. I believe the only competitive strategy between territories that could shed a certain light on both concepts and bring them together is a strategy based on information and knowledge. This strategy is none other than the one used by complex systems in nature which, as we pointed out, maximises entropy in terms of information (remember the example of humans, the most complex system we know: only requiring 150 W of energy to work).

Information and knowledge in urban systems is concentrated in corporate bodies — economic activities, institutions, associations —, which establish the level of organizational complexity (H) and the multi-varied relationships between information and knowledge, with differing degrees of specialization. Increasing urban complexity means increasing the diversity of corporate bodies and thus, the level of accumulated knowledge that attracts, when a certain critical mass is reached, a greater number of activities that prosper due to synergies provided by growing complexity. Attracting investment rises as corporate body diversity increases, that is, to the same degree that economic and social capital grows.

One way to express urban complexity is linked to information theory. Shannon and Weaver calculated the information contained in a message by means of a measurement of entropy:

$$H = -\sum_{i=1}^{n} \pi \log 2 \pi$$

Ramon Margalef used this same logic to measure biodiversity, that is, the complexity of ecosystems, and I have done the same to measure urban complexity. In the urban environment, the "words" of the message are the corporate

bodies — economic activities, associations and institutions — that are found in a specific territory. They are what make up the organization and its network of multi-varied relationships which allow a city to remain organized over time and for its complexity to increase (or decrease). They are also where information and knowledge are amassed.

An expression of an urban message — of the level of urban complexity — could be: [fig. 1]

The value of H, applying Shannon's equation, is in bits of information per individual.

This is a value provided by the information contained in the message. In principle, this is quite a lean message, which could increase especially if we were able to determine the degree of relationships that exist among the members of the message; for example, knowing the monetary, material or information flows among them. Unfortunately, attempts to establish these relationships collide with the hermeticism of the institutions that have that data.

In any case, the measurement of H becomes interesting when it is applied to a territory and different parts of it are compared, or their evolution is analysed over time [fig. 2].

The increase in urban complexity should be accompanied by an increase in knowledge-dense activities, that is, activities with information as added value, also called @ *activities*. In the city, information as an added value is not only found in new activities such as ICT. It is advisable to spread it to all urban uses and functions.

Examples of the practical applications for the development of model of a knowledge city include: Buildings with @ (bioclimatic buildings, for example), homes with @ (domotic application), public space with @ that incorporates information through "intelligent" design and furnishings, services with @ (hotels, schools, health centres, etc.), or consumer goods with @ (for example, if the important thing is to see images, technology today enables us to obtain images that are three or more metres wide with devices — projectors — that are miniscule, so that it is not necessary to see them on televisions as big as four-door cupboards, which makes obtaining large images compatible with a dematerialization process).

Reducing resource consumption and, at the same time, increasing information and knowledge are part of the same equation. The sustainable city model cannot be achieved without developing the knowledge city model, and the knowledge city has no future without the development of the sustainable city model.

The parallel development of both models lets us tackle the two major challenges today's society currently faces: on one hand, the entry of information and knowledge into society and on the other, the need to reduce the ecological problems presently facing our planet, the result of the growing pressure exerted by human systems in general and urban ones in particular on the Earth's ecosystems as a whole.

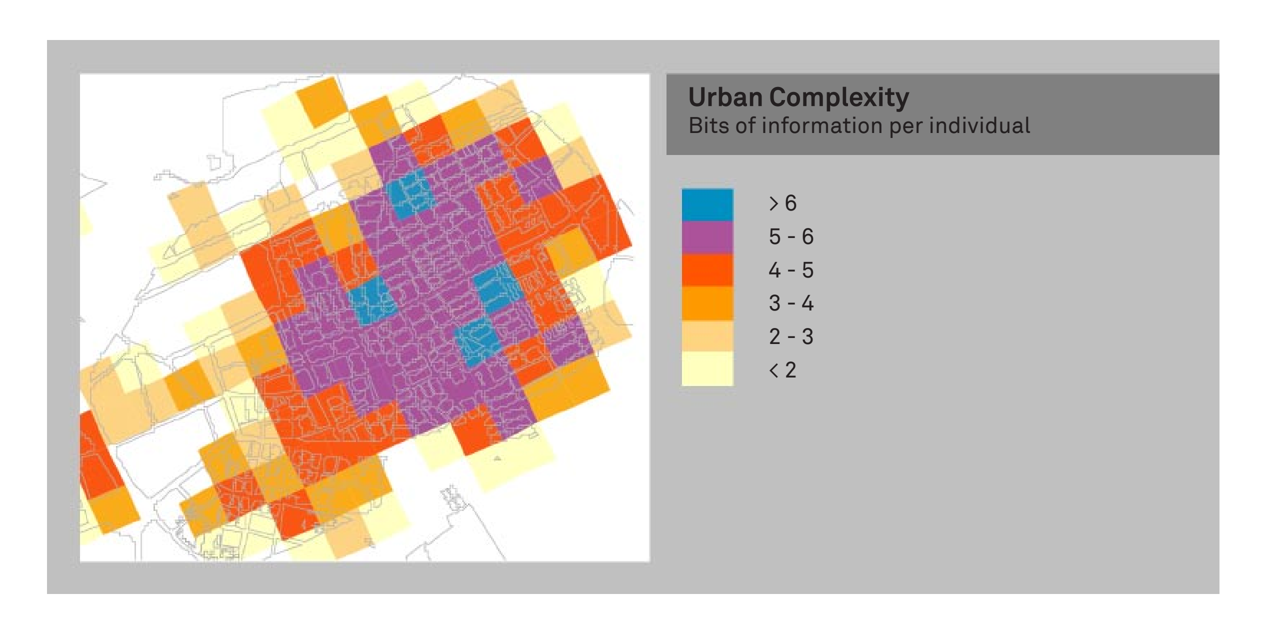



**Figure 1.** Measurement of the urban complexity (H) of Prat del Llobregat (Catalonia).

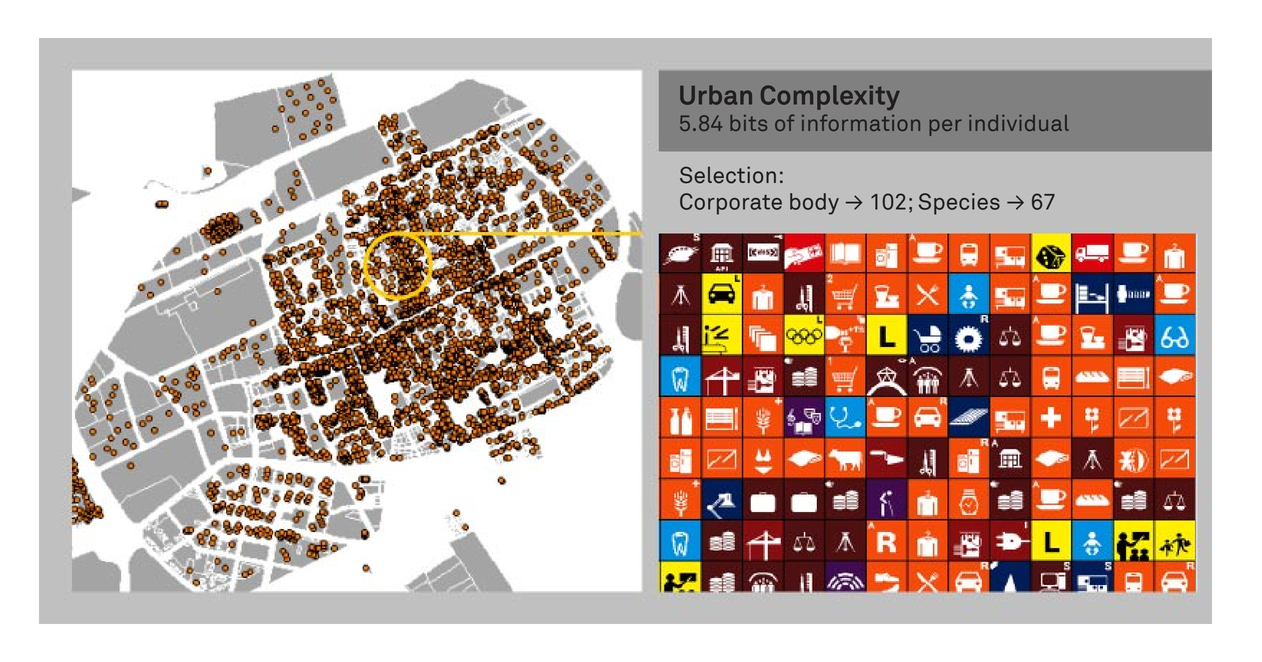



**Figure 2.** Urban message of a selected territory of Prat de Llobregat. The quantity of information of the selection's message (H) is 5.84 bits of information per individual.

# (Metagraphs)
# TOTAL QUIDATION
# Words, Men and Time

José Antonio Millán

The human language is a highly complex code that is made and remade in the network of communication whose nodes are people. Emerging fragments of that code crystallize in writing: billions of words stored in servers and kept in libraries, and millions of others that are exposed to the public eye (and action): epigraphy, posters, graffiti and so on. These will be our subject.

Words in any language in the world are the combination of a fistful of elements called phonemes, whose number is never less than twenty and never more than half a hundred. Languages written with alphabets involve a graphic variety of about the same size. Spanish, for example, is written with twenty-seven letters. This means that, deep down, any word is quite close to another (as Lewis Carroll found out in his stunning routes of transformation).

Public words (those of monuments and public or private posters) are exposed — to the elements and to the action of people. From time to time, a letter falls off, threatening the meaning, changing its point of reference or making it cryptic. The ill-intentioned or amusing action of humans can also alter messages, derailing their original meaning through a clever use of gaps or proximities in verbal codification.

An existing work is an axis around which possible words revolve in the combinatorial potentialities of a language. In the ideal matrix of all possible words (those that exist only in the Library of Babel), real words stand out here and there. Man and chance trace the paths that connect them, and the present is a partial map of those paths.

**(The *Metagraphs* project is developed in <http://jamillan.com/metagrafias>)**




# I
# Men




Do not prohibit



















Playing with the Most Sacred

**1** Barcelona, 2002 **2** Formerly "DISPOSING OF RUBBLE OR REFUSE IS PROHIBITED OFFENCES SUBJECT TO PENALTY." Valencia, 2003 **3** Barcelona, 2006 **4** Gerona, 2007 **5** Barcelona, 2002 **6** Barcelona, 2007 **7** Formerly "Carrer del Cardenal Vives i Tutor". Archbishop Tutu was awarded the Nobel Peace Prize in 1984. Barcelona, 2002 **8** Formerly "Dragados [dredges]", Barcelona, 2007
















Evil Intentions




Correcting







Let nothing remain
















# II
# Time








Disorder

**9** Formerly “Contracts and works”, Zaragoza, 2006 **10** “Curture!” Door plaque. Barcelona, 2002 **11** Barcelona, 2005 **12** Tarazona, Zaragoza, 2005 **13** Formerly “City government”, personal website, 2006. oil. *vb. colloq.* To corrupt or bribe someone with gifts or money. **14** Formerly “Royal oratory”. *Orto:* “arse” in Argentine slang. Madrid, 2008 **15** Formerly “All your books are at this point”, “… for people for whom reading is the point.” Point of sale, Barcelona Metro, 2003 **16** Formerly “NO SMOKING PLEASE”, then “NO FUCKING PLEASE”. Elevator, Madrid, 2007 **17** Formerly “EROTIC MUSEUM”, then “USE EROTICA”, Barcelona, 2007 **18** Formerly “Rubber stamps”, Madrid, 2008 **19** Mexico City, 2008 **20** Barcelona, 2002 **21** Inscription made during the Venetian Republic, erased by Napoleon’s troops in 1797. Italy, 2007 **22** Madrid, 2007 **23** Mexico City, 2005







Interrupted message













Raised and Hunted










The Persistence of Suffixes






















Coda

**24** Madrid, 2005 [...] **29** "Hunted", Madrid **30** "Elevated", Barcelona, 2007 **31** For your horse or for your hair? Mexico City, 2008 **32** "Get down to it!" Madrid, 2008 **33** A *colmao* flamenco joint, Barcelona, 2006 **34** Wordplay on "smoked" and "more", Madrid, 2008 [...] **39** "So-and-so liquidation", Barcelona, 2008

Hiperplaza/ Espacio multicapa
Proyecto Plaza de las Libertades, Sevilla/ Zona activa

PLAZA FÍSICA

Usos

Ámbitos

Soportes media

Plaza web / 3D

Nodos

Redes sociales

Fuentes multimedia

Eventos

Bases de datos

Convocatorias

Información cultural y contenidos artísticos

Plazas globales

PLAZA DIGITAL

1 La plaza como Sistema Operativo

INTERFAZ

O.S.

2 La p… Noc…

Wikiplaza en el proyecto Plaza de las Libertades, Sevilla 2005.2006

HACKITECTURA.NET
(with Morales de Giles Arquitectos and Esther Pizarro)
***WikiPlaza / Plaza de las Libertades, Seville***, 2006

*WikiPlaza / Plaza de las Libertades, Seville* explores the translation of practices and tools used by digital communities to the construction of a hybrid public space, a citizens' cyborg territory. The project won the international contest for setting up and building a space for freedom *(Concurso internacional de ideas para la ordenación y construcción de un espacio para las libertades)* held by the Seville City Government. It is a 30,000 $m^2$ public space and a 3,000 $m^2$ sociocultural building across from the Santa Justa High Speed Train Station, one of the main entrance points to the contemporary city, one of the primary intermodal nodes. The urban development plan consists of a topological, fluid, non-hierarchical space. The contribution of hackitectura.net is related to the



WikiP

hackitectura.net

plaza como
do Activo

3 La plaza como
Interfaz

4 La plaza como
Espacio
electromagnético
ciudadano

social networks

events

Ciborgs rebeldes

incorporation of a multi-layered architecture of networks, hardware, software and digital data that permit the social, participatory production of a public space, as imagined by Lefebvre or the Situationists. The space would be a laboratory for citizens to explore the social uses of technologies, especially matters such as architecture as an operating system, public space as an active node on the web, building social and urban interfaces, electromagnetic public space, the *detournement* of a video surveillance system via permanent public web cast (the square as Mille Plateaux), the invention of new relationships between electronic and natural flows (a garden of microchips), or building public space like a wiki. This is the development of the concept of *WikiPlaza*.

The digital project proposes the implementation in a permanent public space of experiences accumulated during the second decade of the World Wide Web by social movements, which may include








Plaza

2005.2008

Cyborg territory
como agenciamiento
machinic ecology

architectural spaces
spaceware

netware
hardware
software

5 La plaza como
Ecología mediática
ciudadana

7 La plaza como
Wiki

Proyecto gestión
Proyecto hard/ soft
Proyecto edificación

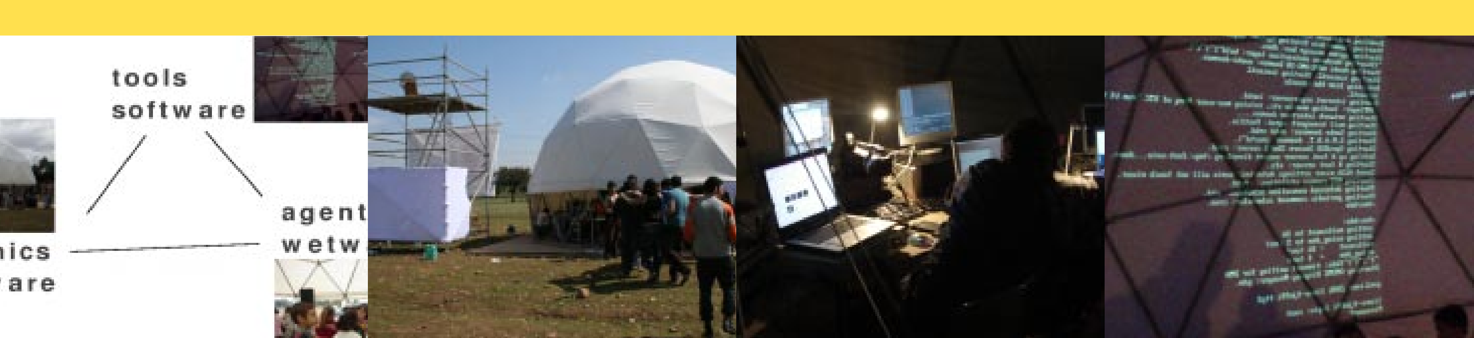
Producción social
del espacio

6 La plaza como
Jardin de Microchips

hackitectura.net y colaborador@s
http://mcs.hackitectura.net

the development of free software, Indymedia, the hackmeetings movement, temporary medialabs, GISS (the global network for free streaming), social centres occupied by squatters, practices considered in a complex sense — sociotechnical, biopolitical, or ecosophical; that is, as generators of new forms of habitation, of being in the world and society. As opposed to traditional architectural and urban development approaches, "Freedom Square" (*la plaza de las libertades*) is conceived as a dynamic *agencing* of physical spaces, social networks, and electronic flows. The project offers a basic infrastructure for the development of an emerging system, a new type of hibrid institution, that we are beginning to see in different places where new forms of autonomy are explored; that is, of relationships between the government and the communities producing the space.

**H.**



1 Geografías emergentes

2 Medialab temporal

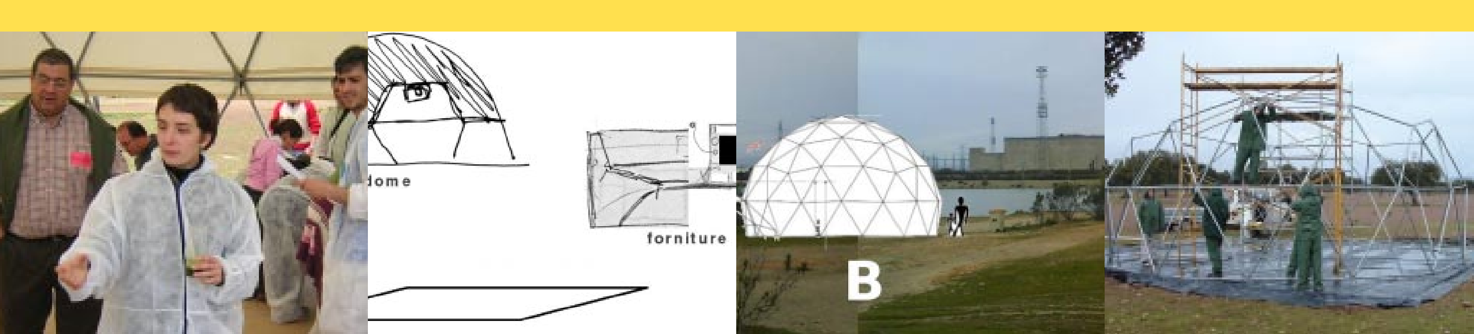
3 Terr

GeoLa

hackitectura.net 2

HACKITECTURA.NET
***Emerging Geographies***, 2007

*Emerging Geographies* explored unusual territorial experiments starting in places on the periphery of the European and global context which are now becoming central to the contemporary redefinition of relationships among technology, creativity, and society. Extremadura was one of the places, a geographic region on the Southwestern border of the continent, a world pioneer in migrating to free software with the Linux operating system. Latvia was the other place, a former Soviet republic on the Baltic which has managed to recycle techno-military installations from the Cold War for civil, artistic and cultural uses.
*Emerging Geographies* investigated the potential of a bridge for cultural exchange between Extremadura and Latvia in this freeing, “glocal”, fluid, machinist and futuristic context.



ritorio Ciborg

ab

007

4 Nuevas mitologías

5 Metaverso

[[[i]]]
Internet

DEAF, Rotterdam

Outer space

Cyberspace

Global

Local

GISS
TCS2
streams

GISS
network
streams

BCN
team

Calamaro
Planet
Second Life

Internautas

Red NCCs
Extrmadura

Eventos

Diagrama Geografías Emergentes
TCS2 Extrmadura 2007

1 Geodesic Dome / control room
2 Satellite Van
3 CNV:: Central Nuclear Valdecaballeros
4 School
5 NCC Valdecaballeros

The project took place in three phases in Merida, Latvia and the Siberia of Extremadura with ten young Spanish and Portuguese participants chosen through a scholarship contest.
Phase 1 was theoretical in nature and took place in Merida with the presence of people including Kristine Briede (Medialab K@2, Karosta, Latvia) and Ewen Chardronnet (Ellipse, France).
Phase 2 consisted of traveling around Latvia with visits to media-lab K@2 in Karosta and the Virac radio antenna as successful examples of the recycling of 20th century buildings and technological installations.
Phase 3 consisted of the installation of a temporary laboratory for artistic and technological experimentation outside the dismantled Nuclear Power Plant in Valdecaballeros in the Siberia of Extremadura (Badajoz). The laboratory participants included artists, hackers, free software developers and country residents, physically



6 Participación remota

Grecia

Valdecaballeros

Rotterdam

7 Constelación

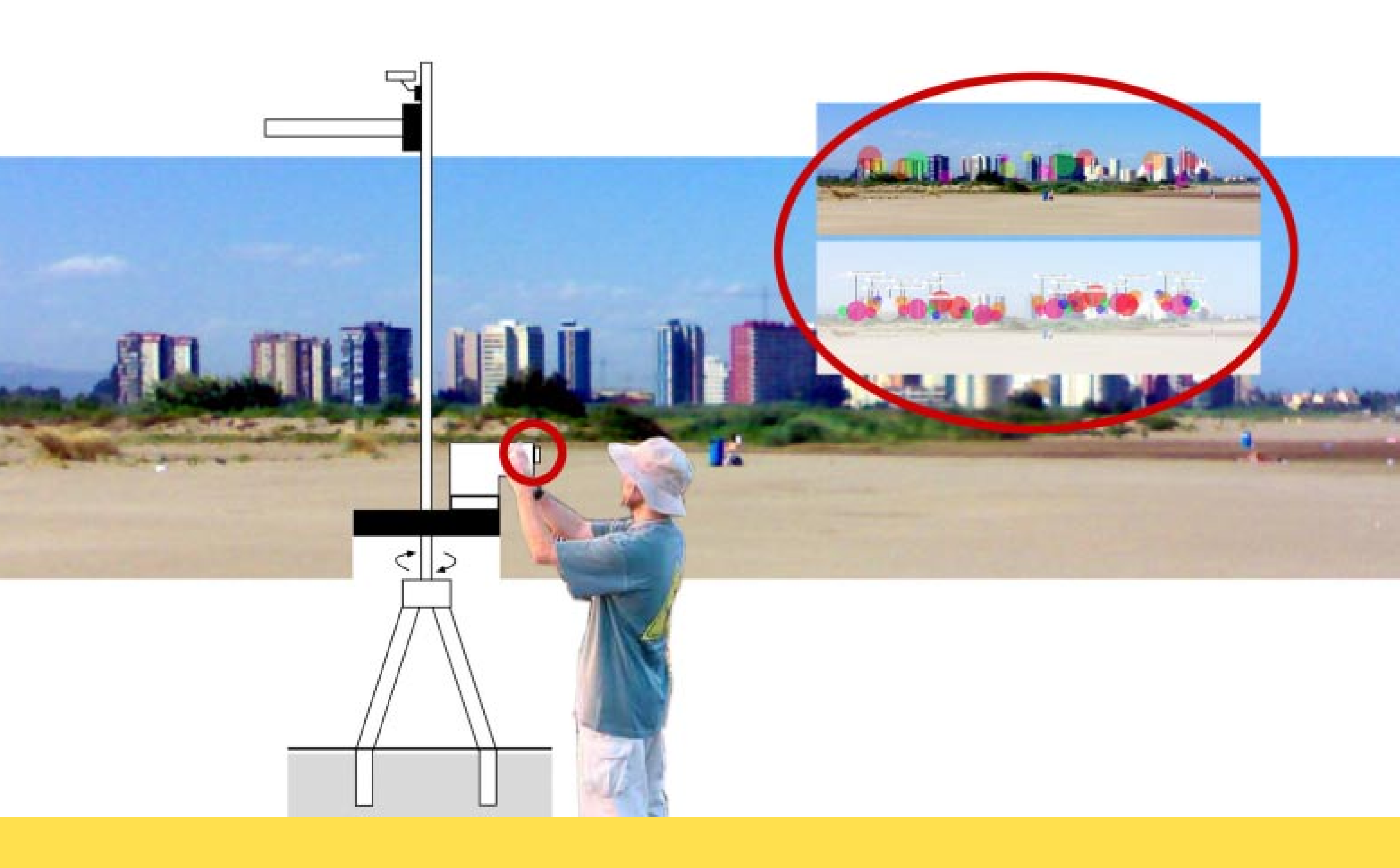
simultaneo

física - digital

located in a geodesic dome equipped with a bi-directional Internet connection via satellite which hosted a series of workshops, panel discussions and performances. The participants included: Clausthome (Riga, Latvia), Carl Biosmark (Karosta), Nicolas Henninger (Exyzt), Brian Holmes, Meskalito Nagual, Straddle3, Joseanito Llorente, and BeastBox (Lisbon).

**H.**



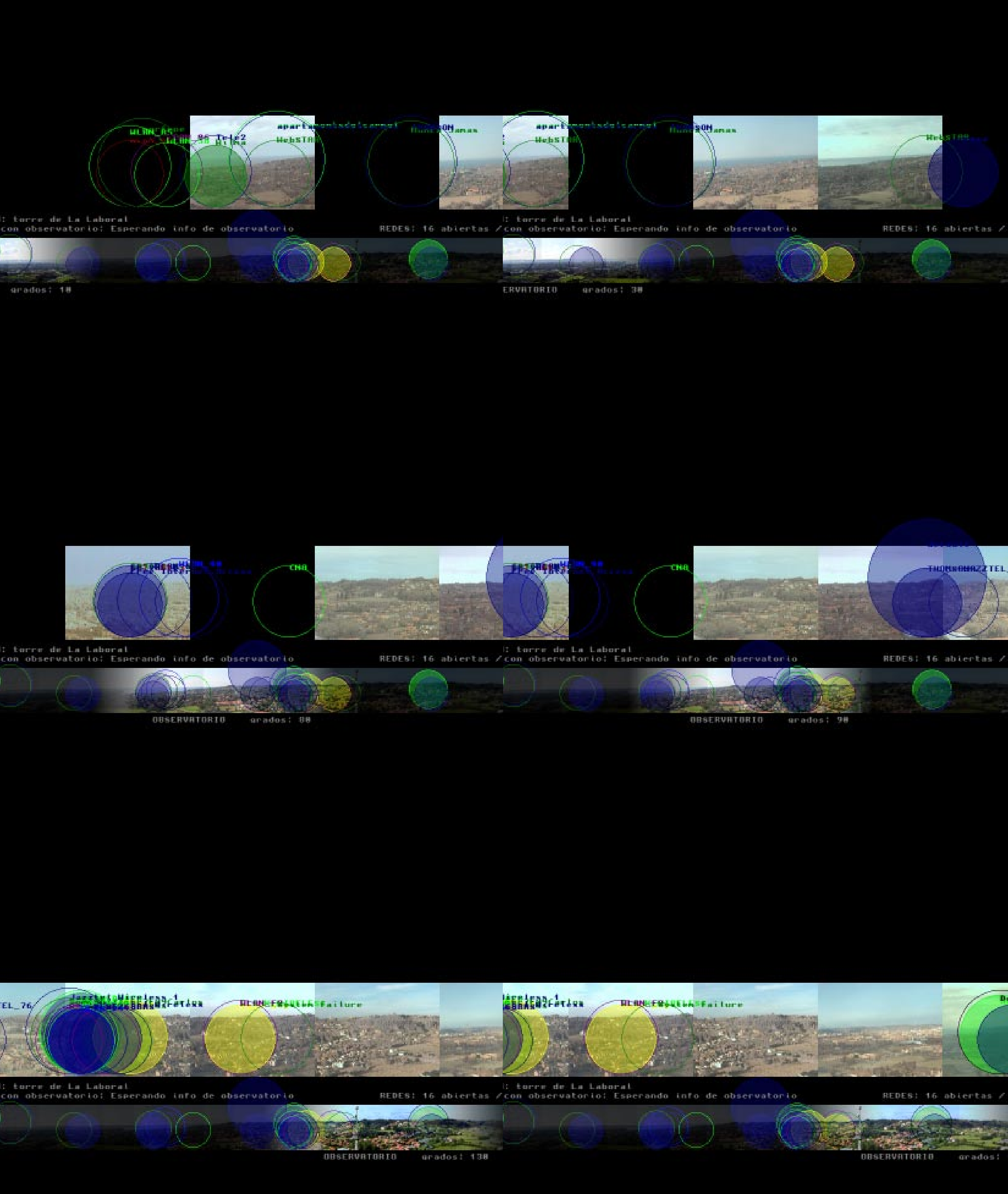


CLARA BOJ, DIEGO DÍAZ
***Observatory***, 2008

One of our previous projects was called *Red Libre Red Visible* (Free Network, Visible Network). Begun in 2004, it reflected on hybrid public space and supported free network social movements. It arose at a time when it seemed possible to achieve the Utopia of a system of wireless, open communication networks managed by social groups offering services to the local community. Thus, a public environment would have been created around them, fostering participation in voluntary organizations, communication, and exchanges among local residents (…). At that time, several city governments began to offer free access to the WiFi network or to foster projects to broaden the coverage area, gradually offering access to the entire city. However, the CMT (Telecommunications Market Commission) denounced those city governments for unfair competition with telecommunications companies (…). Given that situation, all the municipal projects offering WiFi networks were cancelled, leaving the free network groups to handle the tasks of installing, maintaining and extending open WiFi networks throughout Spain (…).
Today, some companies have started to employ other tactics arising from the new situation. These strategies are based on the deceptive slogan "Share your WiFi" and include FON or the recent Whisher and Wefi projects. These companies have realized that the current infrastructure of access nodes to the Internet in our cities could provide



coverage to the whole city if it were an open, shared structure, given that a large number of isolated nodes already exist that could be reordered, creating the global network that was the aim of the Free Networks groups (...).
*Obervatory* is a project that aims to contribute a reflection on the scenario described above, informing viewers about the current state of wireless networks located in the area where it is installed. It comprises a device located in urban space that tracks and shows the networks in real time and sends this information to the exhibition hall, where it is displayed while a possible modification of these networks is also offered, showing an ideal configuration in which the local residents of large areas in the city could share access to it. In a public square still to be determined, we will install the lookout device. It comprises a high power uni-directional WiFi antenna with a 30º aperture, able to detect wireless networks within several kilometres; a video surveillance camera with a telephoto lens with the same aperture as the WiFi antenna; and a viewer which, like a periscope, offers a real time image taken by the camera, with the WiFi networks detected by the antenna placed geographically on it.
**C.B. and D.D.**



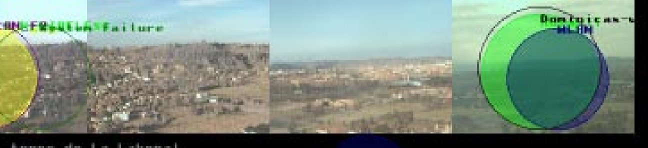
: torre de La Laboral
con observatorio: Esperando info de observatorio
REDES: 16 abiertas /
grados: 10
ERVATORIO grados: 30
OBSERVATORIO grados: 80
OBSERVATORIO grados: 90
OBSERVATORIO grados: 130
OBSERVATORIO grados:
WebSTAR
CNA

: torre de La Laboral
con observatorio: Esperando info de observatorio REDES: 16 abiertas /
OBSERVATORIO grados: 50

: torre de La Laboral
con observatorio: Esperando info de observatorio REDES: 16 abiertas /
OBSERVATORIO grados: 70

: torre de La Laboral
con observatorio: Esperando info de observatorio REDES: 16 abiertas /
OBSERVATORIO grados: 100

: torre de La Laboral
con observatorio: Esperando info de observatorio REDES: 16 abiertas /
OBSERVATORIO grados: 120



: torre de La Laboral
con observatorio: Esperando info de observatorio REDES: 16 abiertas /
OBSERVATORIO

: torre de La Laboral
con observatorio: Esperando info de observatorio REDES: 16 abiertas /

ESCOITAR

***Air, Sound, Power. Social Control Technologies With Sound***, 2008-2009

"Let sounds be themselves", wrote John Cage, deservedly the most quoted artist. Anthropologist Jacques Maquet claims that "there is a universal aesthetic human response to sound." Llorenç Barber, another visionary, affirms that "sounds are not only symbols; they are acts" and philosopher Dilthey explained that those strange objects — the sonorous — are creations of the spirit, which "we cannot explain — we can only comprehend." Hitting the nail on the head, Michel Schneider, the French psychoanalyst and musicologist, says that the sonorous — music — is "a sort of foreign language that we don't speak but that speaks to us. It knows things about us that we do not." If, In addition to all of this, we consider that the phonograph was invented



almost eight centuries after the printing press — that is, a technology that made the preservation, reproduction and distribution of images possible existed long before the corresponding technology for sound — we are faced with an epistemological problem; that is, we are confronted with the need to build a new theory of knowledge that allows for the study of societies through their collective imagination of sound. An essential role in this new scenario is played by the semantic web, where things are built, not represented: from the figurative level to the pattern, from perspective to immersion, from object to process, from content to context, from reception to negiotiation, from observation to action, and of course, from cerebral autonomism to the distributing mind. It is here, in this new context, where the keys to the solution of the problem may lie, in the terrain covered by Colectivo Escoitar.org.
**E.**

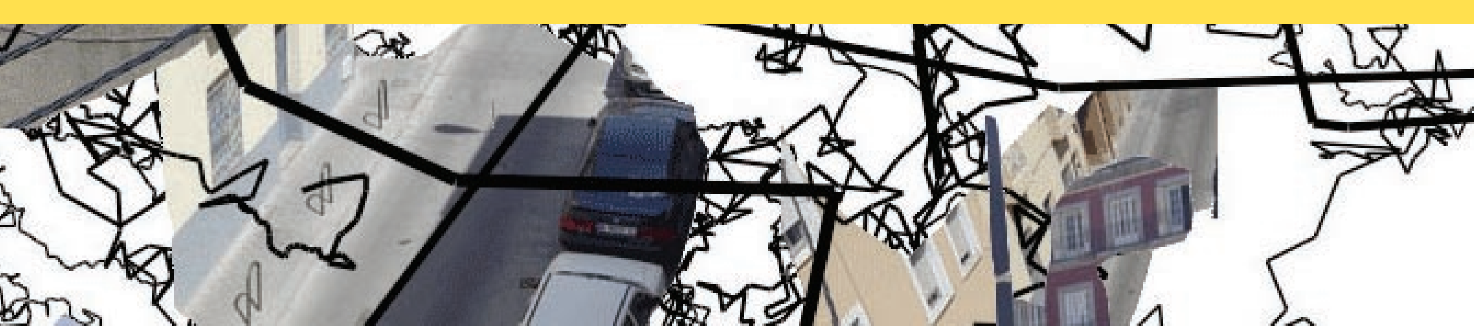




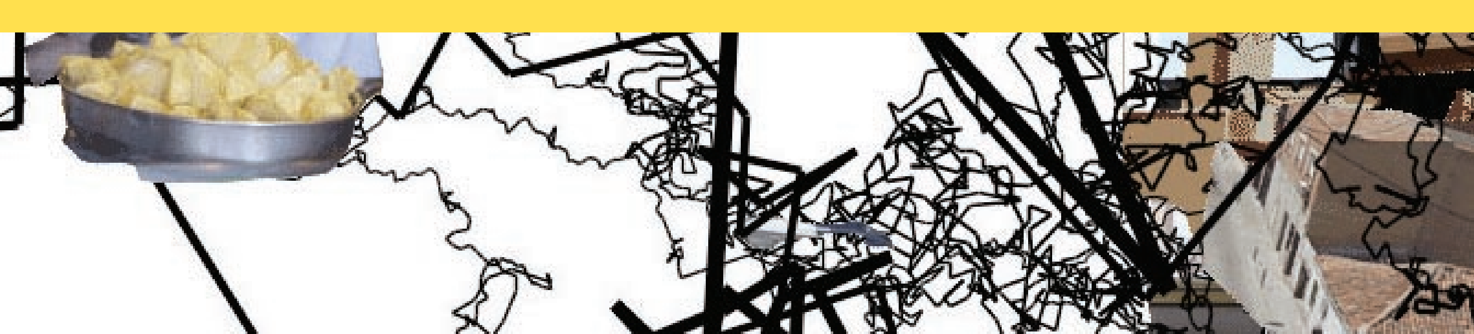


INFLUENZA
(Raquel Rennó, Rafael Marchettl)
***Madrid Mousaic***, 2005

The project uses approximately 500 photographic images of the city of Madrid offering different points of views which, when combined, create various narrative possibilities. Each group of images generates a whole that is rearranged as other images are incorporated and altered, based on the dataflow generated by sound captured on the streets and Metro of Madrid, mixed with ambient sound captured at the time the installation is on exhibit. The project aims to work at the most abstract level of urban data, like a rough mass that allows us to create an aesthetic semantic whole, mixing “real” sounds and images to create new combinations that generate a result between the symbolic and the abstract, which gave rise to the neologism “Mousaic”, something between a mosaic and a muse, two



words with similar semantic roots. The objective is to emphasize the fragmented, residual character of urban spaces and the digital environment. The project seeks to portray the relation between urban space and social groups from a fragmented perspective, which allows for the continuing reconstruction of new narratives. The fragmented message constantly incorporates new social, material and informative elements. The noise of the streets as people walk along, of summer neighbourhood fairs are presented as a metaphor for a city like Madrid, which, like all large cities, can only be experienced in a fragmented, multiple way. The subject belongs to one or more small centres, and creates different narratives (and different meanings) of the city. Creation in digital media has a direct relation to that fragmented subject and the project seeks to relate experimentation in social networks with computer networks. **R.R.**







***We need a change of paradigm based on strategies of low consumption and sustainable technology. And this can only work through processes of international cooperation built on network models and processes. Now more than ever we need a cooperative worldview.***

**José María Baldasano**

# Financial markets and the creation of money in the cybersphere

Óscar Carpintero
José Manuel Naredo

What are the consequences of the dense worldwide network of media, connections and waves on human behaviour? This article does not aim to compete with the broad scope of literature that attempts to answer the question but merely to examine some of the consequences related to the globalization of financial markets and the new forms of creating money in the broad sense that those markets enhance. However, we will place the subject in the broadest social context in which the new social networks that the "cybersphere" is weaving interact with the old ones that social relations have created over the course of human history.

In a society as polarized as ours, the "multimedia revolution" has had quite different consequences at the two extremes of the social pyramid: in the world of business, politics, power and knowledge, on one hand, and on the majority of people, on the other. If active use of the new cybersphere is going to turn the earth into a global village, this is true especially for

the conglomerate of transnational corporations, financial operators, and intelligence and defence bodies, which operate in close osmosis with the academic world and opinion formers, while the majority of people only participate as users of the new devices that now devour their time, especially as mere television viewers. Therefore, while networks are being built to enable a global village of the rich, cultured and powerful, an invasion is being carried out against the time formerly used to nourish bonds of closeness that wove the social networks integral to "local villages", neighbourhoods, conversation circles, and the participation of societies in the everyday management of their problems and nearby territories. And therefore that revolution may have the double, disturbing effect of weakening the *demos* of our "democracies", which are increasingly less participatory, and enabling the global dimension of networks and messages linked to power and business.

They include the appearance in real time of stock exchange quotes on electronic boards in global financial markets. This constitutes a paradigmatic example that enables unprecedented means of financial creation, which also alter the former links between power and money. This has led to significant mutations in the nature of the social convention we call "money". Beyond "legal tender" (bills and coins) or "bank money" (loans, deposits), the processes that have rearranged property and economic and business power through mergers and acquisitions, led by large multinational corporations, have put a new system into circulation to finance those mergers and acquisitions. Indeed, cash payments have been avoided by using as currency the shares that those corporations issue (through capital increases), which they later exchange for shares in the company acquired. Thus, we can speak of a new type of money that could be called "financial money" that does what legal money traditionally did. The difference, however, is that the agent with the power to issue it is no longer the State, but rather certain companies with sufficient power to establish new rules. But first of all, let us look at the breeding ground that serves as a context for this economic phenomenon.

## The process of *financialization*

The financial system is usually presented as a set of institutions and instruments that aim to cover gaps between the income and expenses of economic agents (nations, corporations, households and public administrations). When income is higher than expenses, the economic agent in question generates savings that turn into the capacity to finance other agents whose expenses are higher than their income and who need financing. Therefore, the finance system should connect units with financing capacity with units that need financing. There are two ways to form that connection: directly, through capital markets (stock exchanges, where supply meets demand), or indirectly, through financial intermediaries (banks and credit institutions), which channel the surplus funds deposited by some agents for the investment or expense of others who need it. In both cases, these transactions are materialized in instruments called "financial assets (or liabilities)".

It should be pointed out that in the past three decades we have witnessed spectacular growth in the financial sphere on a global scale,

within rich nations — and those called "emerging markets". This remarkable growth in financial circles has occurred in quantitative and qualitative terms. The trend has been called the "financialization" of the economy.

The process has had numerous manifestations and can be analyzed from various perspectives but it can be summed up as: the progressive autonomy of the financial sphere with respect to the evolution of the "real" sectors linked to production and consumption. Firstly, this autonomy has manifested in much greater growth in financial assets with respect to variables like gross domestic product (GDP) and non-financial investment or gross fixed capital formation (GFCF). As shown in Table 1, in the last twenty-five years, the average annual growth rate for financial assets on a global scale has practically doubled the growth rate of GDP and GFCF. That certainly explains the distances observed upon comparing total world financial assets with respect to GDP in 1982, a ratio of 1.2, whereas the same ratio had quadrupled by 2006. Or when we compare it to investment in fixed capital (GFCF), where the relation also practically quadrupled over the same period, with financial assets seventeen times higher than real (non-financial) investment for that year. These results can be illustrated at the national level with many outstanding cases.

A second manifestation of this process has to do with the internal re-arrangement that has taken place within the structure of world and national financial assets (liabilities). While bank loans were traditionally the privileged instrument for channelling savings and funds from units with financing capacity to units in need of it, for several years now, things have changed. Intermediate financing is no longer the basic source for gaining funds. Instead, most of that activity is carried out by financial markets via investment or pension funds, or through the direct issuance of fixed-income or equity securities. Credit, which in the early 1980s comprised almost two thirds of total world financial assets, now makes up only one third. This noteworthy loss of percentage is due to stock exchanges taking off, from the standpoint of shares, bonds and debentures (public and private).

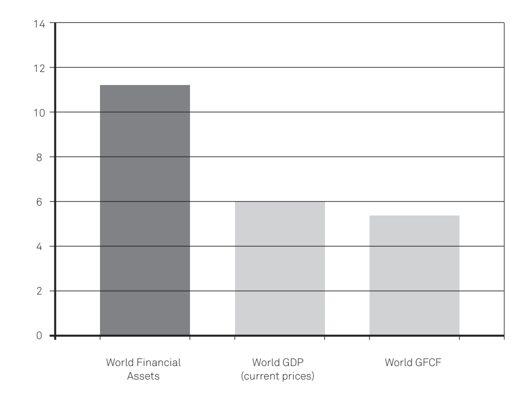



**Table 1**. Growth of Financial Economy Versus Real Economy, 1982-2006 (compound annual growth rate). Source: Own calculations based on IMF, *Global Financial Stability Report*, UNCTAD, and Bank for International Settlements.

## Rich countries: largest debt and smallest savings

Debts (liabilities) incurred by a nation (through its corporations, households and public administrations) are usually twofold in nature. On one hand, they are comprised by repayable debts, that is, external resources that involve the

obligation to return the principal plus interest (loans, bonds, etc.). On the other hand, there are non-repayable liabilities, primarily comprising company shares, their share capital, also called equity. There are two key differences between the types of liabilities worth highlighting.

The first difference is that, while the value of repayable debt is known beforehand and what the economic agent is obliged to return is known, in the case of non-repayable liabilities, the situation is quite different. If the shares are traded on stock markets, the company that issues them is not obliged to reimburse the shareholder for the same monetary amount (or more) if the shareholder wants to sell them. Instead, their value depends on the stock price at that time. That circumstance turns shares into a form of wealth with a high "virtual" component, given that the price of shares is inversely related to the number of owners wishing to sell or unload them in the market. In fact, it is well-known that their value plummets when all the shareholders simultaneously want to materialize their desire to sell.

There is an additional factor to point out, related to the asymmetry suffered by different economic agents when they aim to finance their debts. While the State and companies can issue repayable and non-repayable liabilities to obtain additional resources, households, in contrast, can only go into debt with repayable liabilities provided by credit institutions. Naturally, the capacity that nations or companies have to issue their non-repayable (and repayable) liabilities and for them to be accepted on markets depends on their economic power in the broad sense, which means that this possibility and its intensity is not within everyone's grasp. In fact, this is the difference that has made it possible to keep poor nations under the stigma having the largest foreign debt — understood as a repayable debt — while it was actually the rich nations who have higher debt, but it was not recorded for these purposes given that in many cases non-repayable liabilities were involved.

This distinction between payable and non-repayable debt is quite significant, especially when linked to the dynamics of "financialization" at the international level. Both form a basis for presenting two finance models, within which nations can be classified. First of all, we have the "chronic capital draw" model. These countries attempt — through a variety of mechanisms and instruments — to capture the rest of the world's savings to finance their internal consumption and their international acquisitive expansion. Table 2 shows how, in

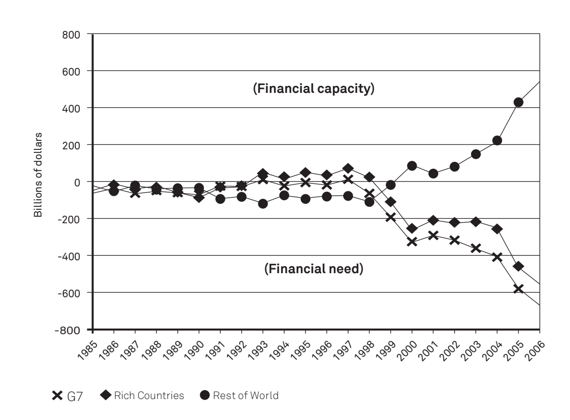



**Table 2**. Debtors and Creditors at International Level, 1985-2006 (current account balance).
Source: IMF, *World Economic Outlook Database*. Rich countries are the 31 nations that the International Monetary Fund classifies as "advanced economies" based on per capita income.

"global" terms, nations using this model (many rich nations) have a large cash deficit which is offset by their ability to attract the savings of the rest of the world, which are deposited in their bank accounts or used to buy liabilities issued on financial markets.

In fact, heading the International Monetary Fund's list of top debtor nations in absolute terms is the United States — the country also said to be the "richest" in the world — followed by Spain, the United Kingdom and Italy. In 2006, the US economy drew almost 60% of all imported capital flows on a global scale, while Spain appeared in second place with almost 8%, followed by the United Kingdom and Italy. In addition, when current account deficit is measured in relative terms (with respect to each nation's GDP), since 2005, Spain has been the world's top debtor nation in relative terms (7.4% of GDP), ahead of the United States.

To offset this behaviour, there is a second, "creditor" financial model. Those that espouse it consider that it offers more heterogeneous features. At the core of the process, the objective has always been to cover the growing financial imbalance of the US economy. Traditionally, that imbalance was practically offset by the savings of two other rich countries, Germany and Japan, up to the 1990s. Since then, however, although Germany and Japan have maintained their surplus behaviour, the voracity of the US and other rich nations with larger deficits made it necessary to include a significant portion of the savings from poor nations (some are called "emerging economies"). In fact, paradoxically, for almost a decade now, the savings from territories such as China, countries in Southeast Asia (Korea, Singapore, Taiwan, etc.), Nigeria, Algeria, Libya, Kuwait, Brazil, Venezuela and, to a lesser degree, the rest of the "poor" world have been financing the imbalance of more economically powerful countries.

This situation completely calls into question one of the most widespread conventional economic theories. According to standard economics, the explanation for rich nations' wealth should be based on higher savings rate which, in turn, enables them to invest those resources to increase their production and income and direct their investments abroad. In the case of the poor nations, the opposite should happen.

However, figures prove contrary to what theory presupposes. Considered globally, savings rates in rich nations, as a percentage of their income have fallen and are lower than savings rates for the rest of the world (which is mainly poor). In addition, since 2000, an even larger divergence has occurred between the groups. In many poor nations of the Americas and Africa, despite higher savings rates than they had previously, their liabilities are often higher than the investments required in their own territories, which shows that their meagre national savings, instead of financing their own investment costs, has been used to finance investments in richer nations or companies domiciled in those nations.

It seems that rich nations, instead of complying with the thesis that they are wealthy because they save more, invest more, and therefore, generate more income, frequently do the opposite: they are richer because they are shown to be capable of drawing the savings of the rest of the world by issuing liabilities (repayable and non-repayable) that enable them in turn to feed the acquisitive strategy of their

companies and households domestically and abroad, through the purchase of assets in other territories. Companies and States, moreover, possess an additional advantage: their ability to issue non-repayable liabilities (money and shares) is not only a privileged form of financing but also enables them to obtain resources with which to amortize the repayable portion of their debts, be they public, bank loans or corporation obligations.

Something similar can be said of new issuances and capital increases carried out by listed companies. In several countries, the stock exchange bubble was fed by these transactions, such as the case of the United States in the late 1990s. In 1999, the amount of US shares in the hands of non-residents as a result of direct and trading portfolio investments was up to 68% of the US economy's total liabilities (debt). That is, over two thirds of that nation's debt was in the form of non-repayable liabilities, although when the financial bubble burst in 2001 and 2002, those percentages dropped to 40 or 45%.

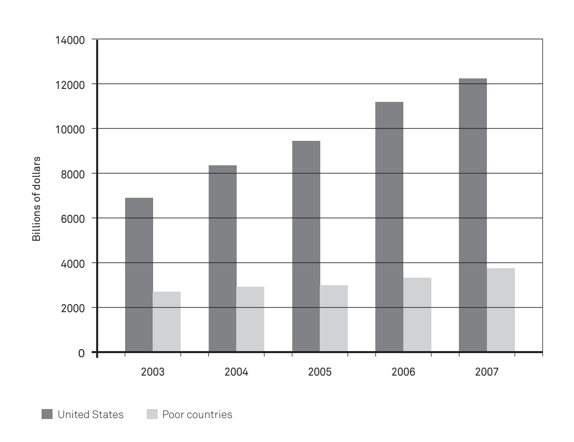



**Table 3**. Gross external debt in United States and poor countries, (2003-2007).
Source: World Bank. *Quarterly External Debt Statistics*.

As a result, in accounting terms, the United States is the world's top debtor nation. Its net debt position, that is, its assets less its liabilities compared with the rest of the world, was over 2.5 trillion dollars in 2007. And its gross debt compared to the rest of the world dwarfs the often mentioned debt of poor nations, as shown in Table 3. The difference lies in the fact that a considerable part of the United States' debt comprises dollars, shares or other non-repayable liabilities, whereas poor nations' debt is made up of repayable liabilities, generally valued in dollars, with firm repayment commitments.

### "Financial money" as fuel for the process

Let us go back to the beginning now and look at the economic mutations and changes in the nature of money hidden behind these figures. Traditionally, conventional economics has identified three different functions that money, as a financial asset, ought to fulfil for society: *a*) be a currency unit, *b*) be used as a means of payment to carry out exchanges, and *c*) constitute a deposit of value. Initially, money in the form of metallic coins minted by States served all three functions, although later on, paper money came into widespread use for the same purpose, which led to what is known today as "legal tender". Since antiquity, this procedure for creating money was followed by the "creation of money" by the banking system.

Given that banks are only obliged to keep on hand a fraction of what they receive as deposits

(their legal reserve or cash ratio), they can lend the rest to other agents, thus creating "bank money" (which does not have the same meaning as the abovementioned legal tender; instead, it comprises additional means of payment in the amount banks are not obliged to keep on hand). These funds are in turn deposited with other banks, generating new deposits (a portion of which may once again be lent), and so on. This process is used to such a large extent that once again, the pragmatism of national accountants has made monetary and financial statistics include in their classification a section titled "the money-creating sector".

In the majority of countries, given the business mergers and acquisitions underway, a new type of money has been added to traditional procedures for creating money. As we said at the beginning, it can be called "financial money". For many years, quite clearly, business merger and acquisition transactions have been financed thanks to recurring capital increases carried out by the absorbing companies which, via the issuance of non-repayable liabilities (their own shares), obtained the necessary means to finance their acquisitions. On numerous occasions, the shares thus issued served as a means of payment when the purchase was made through an exchange of shares, which is how a company's equity was acquired, financed by means of payment comprised by the purchasing company's shares. This practice was used in the second wave of mergers and acquisitions in the late 1990s, and some of the leading players were several Spanish companies. In the case of Spain, during the last five years of the 20$^{th}$ century, the rise in capital increases and the issuance of new capital to acquire other companies through an exchange of shares ("stock swap") both expanded significantly, amounting in 2000 to the equivalent of 21% of GDP. Behind these figures are huge issuances of "financial money" and "seigniorage", such as the purchase of YPF by Repsol in 1999 through a stock swap in the ratio of 1:1 for a market value of almost 5 billion Euros; BBV's acquisition of Argentaria in 2000 through a stock swap in the ratio of 5:3 for a total of 18.8 billion Euros; and Telefónica's acquisition of its Latin American subsidies in 2000 through various, and mixed, exchange procedures for a total of 24.5 billion Euros.

The mechanism for the issuance of financial money that came to prominence in the Spanish economy in the late 1990s declined in the early years of the 21$^{st}$ century, only to rise again in 2004, reaching a new record in 2007 with figures similar to those of 1999. According to Bolsas y Mercados Españoles *(the Spanish stock exchange operator)*, if we take into account only capital increases (not new launches of shares), Spanish companies last year issued shares for a value of 59.1 billion Euros, of which almost 49 billion were shares used to be exchanged for shares of acquired companies, that is, the equivalent of over 5% of Spain's GDP in 2007. Here is where we find the fuel needed so that, for example, Iberdrola acquired Scottish Power and financed the exchange of shares through a capital increase of 9.5 billion Euros, or the BBVA increase of 196 million shares to buy the US Compass Bancshares for 3.2 billion Euros.

Therefore, one is entitled to speak of financial money, given that it fulfils the three purposes required of money: *a*) it is a currency unit for setting a transaction price, *b*) it is used as a means of payment, and *c*) it is a deposit of value and

wealth for its holder. Naturally, this procedure has not been solely the prerogative of Spanish companies but has spread to all financial markets. In fact, on a global scale, if one compares the evolution of this issuance of financial money (increases and new issuances) with the value of multinational mergers and acquisitions, the correlation is obvious.

The virtual nature of a good portion of this wealth is also obvious, given that the main component of financial money are shares, whose value on stock markets is usually much greater than the money paid and even bigger than the "shareholders' equity" of the companies that issue them. This is what led Rudolf Hilferding almost a century ago to classify the stock market value of shares as "fictitious capital", given that although stock markets allow it to be converted into money through the sale of shares, that can only happen for a very small percentage of all the shares issued, for when that conversion is generalized, plunges in share values lead to panic situations, clear proof of the significance of the fictitious component of that capital.

The stock market, as an expression of the value of the financial wealth of the shares' holders and of the financial money issued by companies via capital increases through the exchange of shares, suffers from the same illusion. One has only to remember the oft-repeated fact that when shareholders decide en masse to sell their shares to realize their investments, share prices plummet as a result, and companies' value on the stock market vanishes. The same can be said of the illusory nature and risks related to the creation of bank money. The phenomena of stampedes of depositors on banks — carried out by people who want to take out their deposits in cold hard cash — show that if there is simultaneous demand to convert a significant amount of financial wealth into cash, a general collapse occurs.

Therefore, one can conclude that the financial game today is a primary instrument in the "acquisition of wealth" by economic agents, however, this game leads to an increase in inequality between those who benefit and those who are harmed, as well as between companies able to create money in the broad sense we have discussed, and those other companies and persons who do not have that ability. In the economic world, this strengthens relations of dominance, whose asymmetrical nature admits close analogies to relations of the predator-prey and parasite-host type, which generate processes of increasing social and territorial polarization.

As noted at the beginning of this article, the processes of the creation of bank and finance money that serve as the basis for what is called the "financialization" of the economy could not have developed without the networks that enable the existence of global financial markets. The cybersphere, with its global data flows, makes it possible for those "virtual values" to exist, namely, exchange rates, financial assets and their multiple derivatives. And it is those quotes, both current and forecast, that serve to attract or disperse the powerful financial flows described above.

Those flows, which only exist as accounting entries, travel around the planet with no materiality. It is difficult to assign them any geographical representation given that not only double entries tend to hide the exact geographical origin and destination of those flows. In addition,

the multiplication of instrumental companies and shares backed by shares, often in conjunction with the existence of tax havens, make "a-territoriality" a means by which business escapes from the legal and fiscal regulations of nation states. Thus, aterritoriality has arisen as one of the effects of financial globalization.

# Science, networks and art: visual arts and ecology

Ramon Folch

## Science as Art

Art expresses the human soul. So does science, for it is an artistic manifestation. I do not say this to provoke but because I firmly believe it. Science is one of the most outstanding forms of artistic expression, although it often does not transcend the level of arts and crafts. However, that also occurs in the visual arts. Science may be excellent or rudimentary, just as art can: there are sculptures and then there are *botijos,* a type of Spanish ceramic drinking vessel. Those vessels are necessary and even pretty but they are not sculpture. Some of them are. But then they are not *botijos.* A *botijo* that is too beautiful and excellent to be filled with water at the fountain for fear of breaking it is not a *botijo,* although its form and properties are those of a drinking vessel.

It is important to keep this in mind. These things seem obvious but I'm afraid they are not. To start with, we have established a commonly accepted dissociation between science and the humanities. It's more than a dissociation: it's a

dichotomy. When I was an adolescent, there were two different study programmes at high school: arts, where Greek was taught, and science, where people took algebra. That was ridiculous because, to understand the world, it's useful to have both subjects in sufficient doses. Things today are different and worse: nobody studies Greek in high school and very few know anything about algebra.

In the charming 19th century building at the Universitat de Barcelona where I studied science as an undergraduate — in the 1970s, there was only one science degree for all: mathematicians, chemists, physicists, biologists and geologists — there was a "Science Quadrangle" and an "Arts Quadrangle." The quads are still there and have the same names, though no one today remembers why. However, in the collective mind, there are still "arts people", though they know no Greek, Latin, or much about literature, and "science types", who are often completely useless at mathematical or chemical formulas, but there's not much we can do about it. I just mention it in passing, in case it's of use to anyone.

This opposition between science and the arts has existed since science rose to the level of the arts in the Renaissance. Prior to that time, there was a sort of arts and crafts type protoscience arising from prototechnologies in everyday life. That lasted until non-speculative thought came to the forefront with the well-known scientific method of approaching the use and comprehension of phenomenological reality through experimentation. One could hardly imagine a more humanistic procedure, beginning with the means to carry it out: one needed to know Latin, Greek and Arabic to gain access to the knowledge of Classical Antiquity, though not all of it was of equal value.

This way of thinking, based on the comparable, repeatable and revocable nature of working hypotheses, had an enormous, unprecedented success. Many of those who officiated at the old rites were unable to adapt and found consolation for that failure in proclaiming themselves the standard-bearers of a decapitated humanism that stole the term. And many of the converts to the new approach got lost in its showy liturgy, forgetting all their faith: they ended up knowing a lot but had no purpose. And so we reach our times, doubting the artistic scope of science and confusing metaphysics with pre-scientific alchemy.

And still questioning the virtues of transdisciplinary approaches. Specialization is not the purpose of knowledge; instead, it limits the person with knowledge. Given that cognitive fields are constantly expanding, each person's skills constantly narrow in focus. The only way to delve deeply is precisely to narrow one's focus. Therefore, the only way to gain a deep and also broad range of knowledge is to form part of a transdisciplinary team. Shared professionality is the corollary of inescapable specialization. Either that, or be a multifaceted genius.

A professional who is part of a group has a transversal outlook; this person is able to contribute his or her sectoral expertise to a meaningful general system. However, merely adding partial skills does not make processes transversal. Something else is needed: an awareness of that partiality and the ability to work on a team. That is the operating principle behind concert music: each performer plays his or her instrument but what is heard is the orchestra as a whole. Many virtuosos playing simultaneously do not necessarily add up to a concert.

Universality should train virtuosos able to take part in concerts. Professional organizations should help them avoid becoming solitary virtuosos, instead of trying to achieve it with very

weak ties to musicians as a professional group. The virtues of transversality and the advantages of a lively curiosity about the border areas must be encouraged. Post-industrial society requires professionals who are part of a group, new *maestros* who integrate skills from a holistic perspective, where the whole is greater than the parts. The time has come for a transdisciplinary approach, which transcends the narrow focus of specialization and is the antithesis of undisciplined generalism. Moreover, it is an artistic gesture that recovers knowledge and experience lost in harebrained pursuits.

## Networks: foundations for life

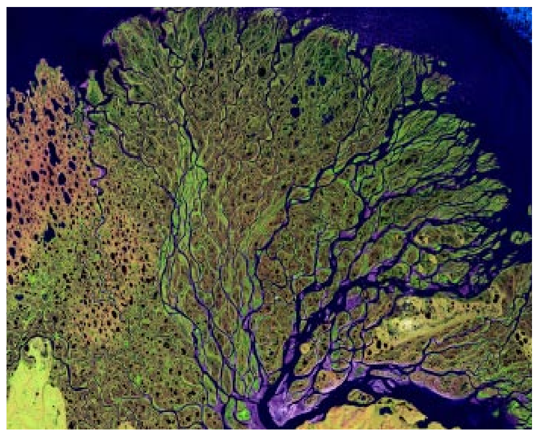
To biologists and ecologists, there is nothing odd about this approach. Life is the improbable result of many fortuitous collisions. Organic molecules are left-spinning — their right-spinning isomers had no luck at all — simply because the first ones that entered the game turned optically to the left and set the pattern. It could have been the other way round, but it just happened this way. Subsequent networks rejected right-spinning molecules, as they could not form proper connections, just as the right hand doesn't fit over the left. To understand it, one needs to draw on physics, chemistry, geometry and game theory, as a start, which shows that transversality lies at the root of understanding biological processes.

Life tends toward networks. That's a fact. Toward networks and symbiosis, which is a network of organisms. Lynn Margulis' Symbiotic Theory hardly needs to be proved, it seems so obvious. The hostile reactions it has encountered demonstrate how difficult it is for "normal" science to modify its hypotheses and shift to another scale. The scientific method plants doubt permanently, to the point of undermining scientists' morale, which must be accepted. It is much easier to believe than to know, and that is the key to the success of revealed religious truths. Scientists, like any other human being, tend to believe what has been proven previously and become annoyed or at least uncomfortable when new arguments make it necessary to revise what had been established. When Margulis says that a eukaryotic cell — mine and yours — is a centaur of various bacteria, it's disturbing to anyone, especially to experts on cells: this was certainly not on the cards.

Eukaryotic cellular corpuscles like mitochondria and ribosomes would then be ancient bacteria symbiotically integrated into the new cell. The same would be true of flagellates, which are nothing more than spirochetes arranged in a new cellular body. A detailed study of these microstructures shows that to be so. The naive question would be: Where else could modern cells have come from chronologically, if not from a recombination of what already existed?

At another scale, symbiogenesis is constantly right before our eyes. Without bacterial flora, we would not be able to digest our food. A symbiont is a species that cannot survive without the species on which it depends. And how and when did that species appear autonomously before the symbiotic relationship was set up? The answer is never, given that evolution has been a joint process for millions of years. Evolution is actually the progress of symbiogenesis. That is, networks of systemic interrelationships are the basis of the very concept of minimally evolved life. In fact, a species understood in the classical sense is not an individual but rather a population of similar individuals interwoven into a complex network of relationships and exchanges. Matter and energy flow through that





Images taken by NASA, project *Our Earth as Art* (Delta Region, Netherlands, and Lena Delta, Russia).

network. Without that network and that flow, the species cannot exist. That is, underneath, each individual is functionally a symbiont of all the other individuals in its own and all other species. The Gaia Theory starts here and goes on to encompass the entire biosphere and the planet.

That ancestral tenacity of the network is replicated in all biological phenomena, including those that seem to have less material substance. Communication via sounds, for example. Isolated populations of certain birds develop specific idiolects that allow them to communicate with individuals in their group but are barely comprehensible to members of other groups in their own species. This can hardly surprise human beings: we certainly speak different languages depending on the group to which we belong. In fact, languages are communicative systems that weave disjointed sound networks through which coded information circulates. We may all use the same system to transcribe phonemes but that doesn't mean that we understand them. A Czech says *pivo* and we understand the sound of *pivo*, but do not understand that it means "beer." Languages are non-material networks that establish differentiating factors among human groups, which explains why we cling to them so fiercely.

They are networks and systems that replicate themselves just as individuals do, by trial and error. By repeating phonemes — that is, by copying their sounds — we make small random changes, similar to genetic mutations. In this way, over time, Latin became incomprehensible to people who believed they were still speaking Latin. Iberian is a dead language because no one speaks it anymore but Latin is not. Latin is a language subsumed into the various Romance languages, just as dinosaurs as a group did not disappear; instead, they turned into birds. Therefore, networks, reproductive replicas, repetitions and evolution are fundamentally one and the same. Life is a vast complex network stretched across time.

### The strange beauty of networks

The drawings by Santiago Ramón y Cajal representing neural networks have been reproduced *ad nauseam*. I'm not surprised: they are fascinating. They suggest a repeatable pattern but also show an organic tremor that makes each component unique. I think that is what makes

them appealing. Each neuron is different but the pattern it generates is predictable. In fact, it is an isomorphism of the human condition: equal but different; similar pieces of a predictible social fabric. Once again, we see the aforementioned ancestral tenacity of the network. That is why we identify with that type of pattern. We discover them time and again as the frontiers of knowledge advance.

That is true of territorial systems in networks detected by observation satellites orbiting the Earth. On 23 July 1972, NASA (National Aeronautics and Space Administration) launched its first satellite for this purpose, the ERTS (Earth Resources Technology Satellite), which was later renamed Landsat. It was actually Landsat-1, given that, over time, there were others: in 2008, we are up to Landsat-7, launched in 1999, and Landsat-5 is still in operation even though it was launched way back in 1984 (Landsat-6 was never put into orbit as its launch failed in 1993). This successful idea was conceived in 1965 by William Pecora, director of the USGS (United States Geological Survey), who first proposed that satellites be used to observe the planet.

The idea was actually extremely successful. Numerous other satellite platforms are now in orbit for that purpose. They usually do so in a heliosynchronic way, so that their sensors gather information from the earth's surface under the same, comparable radiation conditions. This digital information is converted into images that look like photographs but are not, given that the radiation represented is often outside the visible spectrum. In any case, these images are of enormous interest for various purposes and are also quite beautiful.

They are so beautiful that NASA and the USGS, the agency responsible for administering and exploiting the huge amount of data accumulated by the sensors on the six Landsat satellites, launched a programme called "Our Earth as Art." They are like a mosaic of images never seen before, a set of radiant planetary fragments captured by the ETM+ sensors (Enhanced Thematic Mapper Plus) of the Landsat-7 satellite, and also by the ASTER sensor (Advance Spaceborn Thermal Emission and Reflection Radiometer) of the TERRA satellite. In addition to their beauty, these images prove the existence of various outstanding geological, biological, or directly anthropic patterns. The images may be the most eye-catching. They reflect the existence of socio-ecological networks that line the territory. We can hardly consider it surprising, given that it has been established, inasmuch as anything can be established, that a reticular pattern underlies all of life's activities.

Be that as it may, there is another noteworthy aspect of it all. I am referring to the new perceptive horizons that new technologies open up. That was the case with Cajal: what he drew was invisible prior to the invention of microscopes and modern staining techniques, some of which he developed. Today it is occurring due to satellite sensors and new electronic instruments and information technology. I think that's marvellous but also disturbing, given the risks involved.

## The instruments of art

Scientists need tools. Visual arts do, too. The difference is that painters have their photograph taken with their paintings and biologists with their microscopes. Painters present themselves with the fruits of their labour, not with

their brushes, palettes and easels. Far too often, however, scientists believe their credibility rests on surrounding themselves permanently and liturgically with all their tools. A doctor without a white coat or stethoscope is afraid to be taken for a lawyer. That type of representative error has consequences. Visual artists and writers show their works; technoscientists, their equipment. What scientists do with them belongs to the domain of the initiated who read *Nature*, *Lancet* or other journals of that type, but for laymen, it's sufficient to blandish a spectrophometre.

That reduces many scientists to mere potters although they don't realize it. Art resides in sculptures, not chisels, just as cassocks are not where faith and virtue are found, no matter how heavily embroidered they are. Tools are needed to generate scientific knowledge — which is a manifest form of artistic creativity, I insist — but not even the highest quality tools or the greatest skill in using them lead to it. It is a product of creativity and intellectual acuity at the service of the cognitive process. Virgil expressed himself beautifully using a stylus on poorly prepared parchment.

Modern artistic expression based on audiovisual instruments run the same risk. A certain gullibility at the computer keyboard succumbs to the fascination of technological gadgetry. However, just because something makes sounds and changes colour does not mean it is even remotely artistic. With the new palette and new brushes, artists must do more than blow or scribble. I am terribly bored by instrumental exhibits lacking in visual meaning. Experimentation consists of trying to prove or disprove a previously formulated hypothesis; this is also true in art. Mixing reactive substances to see what happens is not chemical research. Exploration is an act of proactive elegance, a series of intentional gestures that tend to obtain the desired results or discover unsuspected spaces, but not random ones.

Formal elegance usually accompanies good scientific propositions, as people in the field know very well. Straightforward algorithms and clear reasoning are anything but simple or easy and are always behind solid theories. By saying $E= mc^2$, in five symbols we have summed up all the complexity of relations between matter and energy. I believe the same is true of visual arts, as in the Golden Section. In physics, $E= mc^2$ by Einstein must be a sort of Euclidean Golden Section, which was later formulated as *=(1+ffl5)/2=1,618033988749...,* that is, an irrational number in mathematical terms, which seems to underlie the majority of things we find harmonious, from a pentagon to a Greek temple, including a snail shell.

What type of exploratory elegance is to be expected from new visual artists experimenting with information technologies and electronics? I do not know. I do perceive, however, a special vibration when they manage to express themselves in a truly artistic fashion. I cannot describe it objectively; it is irrational, an emotional thing. It is art, of course.

### By way of a conclusion: visual art and ecology

I do not know very well what ecological visual arts would be. In fact, I do not know very well what socioecology is, although that has been my field for two or three decades. Socioecology is transdisciplinary, easier to perceive than to define, in which environmental and social knowledge converge. It is the ecology used by society and that makes it possible to understand it, bringing up questions and trying to solve conflicts re-

lated to environmental quality factors. It is configured as a network, though it tends to turn into a tangle, of desires, possibilities and limitations. A complex network that can be translated into artistic representation (beyond art that requires interfaces that are created, convenient for all its users).

If graphic media use photos to explain reality, the visual artist should be able to use the socio-ecological network as inspiration. There is a universe of gestures, departments and flows in socio-ecological management. Viewed properly, it consists of the management of relations between humans and their environment, and among humans, fighting for control over their environment. This epic has an unquestionably artistic dimension. Satellite sensors have glimpsed part of it as it is expressed through territory, which is configured in and translated to networks and fractals. New creators of new contemporary visual arts will have to interpret it in their own way. That interpretation will surely be beautiful and will also contribute to a better understanding of what it represents. Art has always done that.

# The architecture of nature: complexity and fragility in ecological networks*

José M. Montoya
Miguel Á. Rodríguez
Ricard Solé

Ecosystems today are characterized by their accelerated loss of biodiversity. 100,000 years from now, a palaeontologist would classify our era in the history of the earth as a time of mass extinctions. Some direct effects of this loss of biodiversity — for example, the reduction of primary productivity — are relatively well known. Others, which are more indirect but no less significant, are still practically unknown. We are referring to the complex network of ecological interactions. This article discusses some direct and indirect effects, recently discovered based on trophic interactions. These ecological networks are very fragile in the face of disturbances that eliminate the most closely connected species, with the result of a large number of co-extinctions of other species from the ecosystem. We discuss the implications these observations may have in terms of: 1) understanding the organization of ecosystems and their response to disturbances; 2) the relevance and definition of key species; 3) improving estimates of current rates of extinction, and 4) defining objectives within conservation biology.

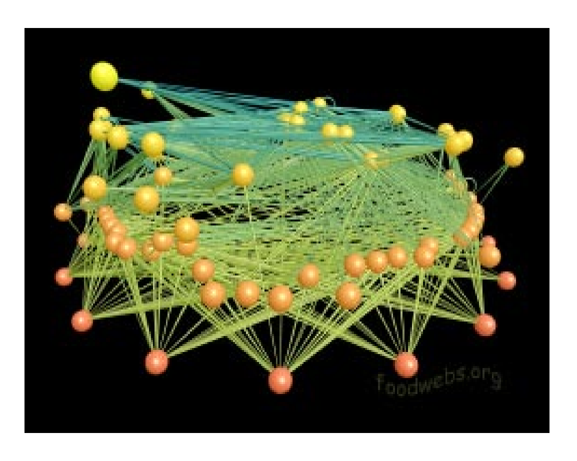



**Figure 1.** Trophic network at Little Rock Lake (Wisconsin, United States of America). Trophic levels are ordered from bottom to top, from the basal level (primary producers, mainly phytoplankton) up to predators at the top of the food chain (mainly fish). The species (spheres) that have a connection with themselves are considered cannibal species, and are relatively abundant; in this network, 14% of the species are cannibal, but in the network at the desert in Coachella Valley (United States of America), this percentage is over 60%. Three-dimensional representation courtesy of Richie Williams and Neo Martínez (San Francisco State University, United States of America).

## Introduction

On what does the fragility of an ecosystem depend? Does the network of relations among species determine their response when faced with different types of disturbances? How does the extinction of one species affect the rest of the community? Are some species more important to the stability and persistence of an ecological system? If that is true, what characteristics do they share? The search for general reliable answers to these questions takes on a special significance today, given the sixth great extinction in the history of the earth that we are provoking and witnessing. The architecture of nature, the framework of ecological interactions, can provide some keys to these questions. E.O. Wilson, in his magnificent book *The Diversity of Life*, illustrates how disturbances are propagated through the ecological network:

> Jaguars and pumas in the scarce intact forests in Central America and South America prey on a great number of species, in contrast to the more selective behaviour of African cheetahs or wild hunting dogs. When the jaguars and pumas disappeared from Barro Colorado Island (Panama) due to the reduction of the size of the tropical forest, the population of their prey multiplied tenfold. The majority of their prey prefers large seeds from the forest treetops. Other species of trees with seeds too small to interest these animals benefited from the lack of competition. After a few years, the composition of the forest changed in their favor. Animal species specialized in the seeds of these trees increased their populations, as did the predators who fed on those animales, the fungi and bacteria that lived as parasites on the trees from the small seeds and the animals who distributed them, microscopic animals who fed on those fungi and bacteria, and the predators of those micro organisms, and so forth throughout the trophic network [Wilson, 1992].

Species relate to each other in different ways, which leads to complex interaction networks. Depending on the type of interaction that we observe, we find networks of competitors, trophic networks, mutual networks, facilitation networks, etc. The structure of ecological networks determines many of the functions of the ecosystems they represent. The recycling of nutrients, water and carbon flows, among many other functions, are altered when the architecture of these networks are lost (Schulze and Mooney, 1994; Levin, 1999).

The graphic representation of an interaction network — its nodes and connections — is called a graph. Knowing the architecture of the graphs of ecological networks will allow us to answer some aspects of the questions with which we began this article. As we will see, the architecture of these networks has points in common with other biological and technological networks, which supports the universality of certain organizational and functional principles in complex systems (Solé and Goodwin, 2001). The consequences of those architectures are surprising and involve a new view of the organization of ecosystems.

## Toward a universal architecture of complex networks: the case of trophic networks

Does a universal architecture of ecological interactions exist? Trophic networks (that is, who eats whom) are the type of ecological network that have received the most attention from ecologists. In the words of Stuart Pimm and collaborators (Pimm *et al*., 1991), "trophic networks are the highwaymen through the tangled universe of Darwin." A trophic network shows all possible food sources for each of its constituent species [fig. 1]. Since the pioneering work of Lindeman (1942) great efforts have been made to find regularities among trophic network and different ecosystems (for the latest compilation, see Williams and Martínez, 2000).

For example, in wide collections of descriptions of trophic networks, similar values have been found for many variables, such as the average number of connections per species, the average and maximum longitude for trophic chains, the percentages of basal, intermediate and predator species, and the percentages of omnivorous or cannibal species. However, there was also a great controversy that arose based on the publication of an article in 1991 by the recently deceased ecologist Gary A. Polis. In that article, the author indicates that the data on which regularities in trophic networks had been inferred were incomplete, biased, and difficult to compare with each other (see Polis, 1991, and Cohen *et al*., 1993, for the criteria data should meet to be valid). Since then, detailed reliable trophic networks have been published on the basis of which some of these regularities are being verified, others abandoned and other new ones discovered. Most interesting of all is the development of an entire field of research on the response of the systems to different types of disturbances, observing and understanding the direct consequences of these disturbances on the network, and the indirect effects that may be caused by their propagation through the network.

Recently new techniques have been developed to analyze the complexity of a large number of natural and technological networks (for a review of the subject, see Strogatz 2001). These techniques have shown that there is a great similarity in the structure and response to disturbances and networks of very different types, which indicates a universal architecture within complex system. This perspective may constitute a true revolution in ecology, comparable to the introduction of mathematical models or multivariant analysis.

Networks, whether ecological or not, can be represented by the graph $G(N,C)$, where $N$ represents the nodes in the network and $C$ the connections among the nodes. Among others, cellular and metabolic networks have been studied (where $N$ represents enzymes or substrata, and $C$, metabolic reactions; Jeong *et al*., 2000);

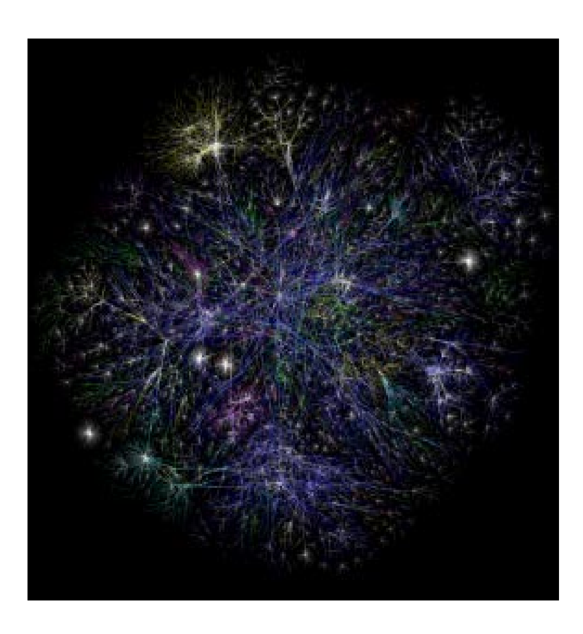


**Figure 2.** Internet. The topology is quite similar to the trophic network represented in Figure 1. More connected nodes and less connected nodes can be seen (What is the node corresponding to "Ecosystems" like?).

the neural network of the *Caenorhabditis elegans* worm (in this case *N* represents neurons and *C,* synapses; Watts and Strogatz, 1998); social interaction network (for example, the network of scientific collaborations, where the nodes are the scientists, and a connection exists if they have published some joint work; Strogatz 2001); Internet, the www (Albert *et al*., 2000) [fig. 3] and other technological networks. All of these networks share the widely known "small world" phenomenon. Basically, this phenomenon has two manifestations: 1) a high degree of component medicalization with respect to what is observed in a network where connections are distributed randomly among nodes, that is, in a network there are groups of nodes highly connected to one another (small worlds) but with very few connections to other groups of nodes, and 2) the minimum number of connections to connect two elements of the network is very low and quite similar to that obtained for a network built randomly (for formal descriptions of these measures, see Montoya and Solé, 2001). Actually, networks with small world properties are halfway between completely ordered, regular networks and completely random networks.

Why is it so important to know the structure of networks? Simply because structure always affects function. For example, the topology of small worlds on the Internet facilitates the transmission of information in a much more efficient way than other types of topologies and, in general, this type of interaction architecture confers a great recovery capacity to systems faced with disturbances of various types.

This seemingly universal architecture is also observed in ecological networks. Two of us have found proof of this universal structure of small worlds in the three most species-rich and best described trophic networks to date (Montoya and Solé, 2001). These networks correspond to the Ythan Estuary, in the United Kingdom (134 species); Little Rock Lake, in the United States of America (182 species), and the land ecosystem associated with *Cytisus scoparius* around Silwood Park (England), with 154 species (for more details on the three trophic networks, see Solé and Montoya, 2001). Prior studios carried out by other authors had already suggested that trophic networks are usually more compartmentalized than random organization would lead one to expect, although the measurements used in those studies analyzed the trophic similarities among species, that is, groups of species that share a certain percentage of prey and predators (Solow and Beet, 1998). Does the topology of small worlds affect basic properties of the ecosystem such as their fragility or persistence? The answer is yes, but before we examine the matter in depth, we will

consider another characteristic of some complex networks, including ecological networks: the distribution of connections among species.

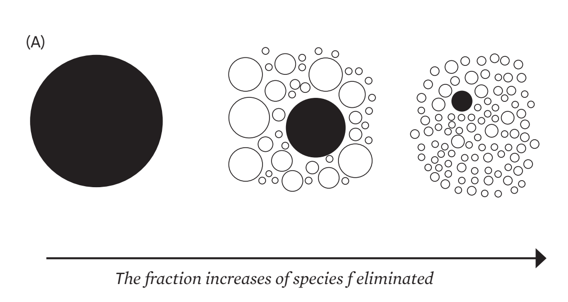
Many networks with small worlds show a distribution of connections via nodes of the potential type. In other words, in these networks, there are many nodes with very few connections and very few nodes with a large number of connections. The metabolic networks of many organisms and the Internet are examples of networks with this type of distribution. Two of the abovementioned ecosystems show a potential distribution of trophic connections by species (the Ythan Estuary and the Silwood Park sub-network), and with respect to Little Rock Lake, although its amounts are not significant, it does show a distribution with a very long tail [fig. 4]. This type of distribution is very different from those in which the connections are randomly distributed through the network, which results in a Poisson distribution [fig. 1].

Networks with small worlds that also have distributions of connections by potential nodes show a duality between robustness and fragility based on the kind of disturbance they suffer. We identify disturbance with the successive disappearance of nodes and therefore of the connections of those nodes with other nodes within the network. Let's imagine two types of disturbance: a non-selective one that eliminates nodes randomly and a selective one that affects the most connected nodes within the network. These networks show high homeostasis in the face of random removals, that is, they recover the conditions they had prior to the disturbance. However, when faced with the selective removal of the most connected nodes, the network is tremendously fragile. In the case of the Internet and the World Wide Web (the first system in which this type of response was observed), a random attack has almost no effects on the structure and function of the network: a very high percentage of nodes could be removed without affecting the global transmission of information. To the contrary, an attack aimed at removing a very low percentage of the most connected nodes (for example, Google, Altavista, Yahoo, etc.) caused a lack of communication among parts of the network that were previously connected quite effectively (Albert *et al.*, 2000).

## The most connected species as "keystone species"

Ecological networks also seem to be quite fragile when faced with the removal of the most connected nodes (species), whereas they are quite robust given the random disappearance of nodes (species). What do we mean when we speak of fragility in this context? We are referring to two essential aspects of the structure and function of ecosystems: 1) biodiversity associated with the removal of species, and 2) the fragmentation of the network into sub-networks disconnected from each other. With respect to the loss of biodiversity, a good measure of the degree of fragility is secondary extinctions, that is, extinctions of species that result from the removal of other species. Specifically, through simulations carried out by computer, we have calculated the fraction of species co-extinguished in relation to species removed (*f*) in the trophic networks of the Ythan Estuary, Silwood Park and Little Rock Lake. Thus, we obtained a secondary extinctions may that can be compared among these three ecosystems.

The behaviour of the three trophic networks is quite similar.  By successively removing species



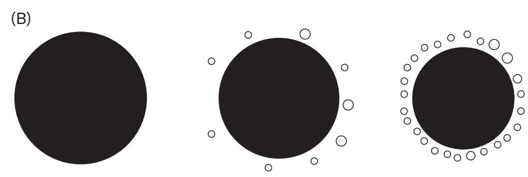




**Figure 3**. Fragmentation of a network (with small world topology and potential distribution of connections) in sub-networks as the fraction increases of species *f* eliminated by: *A*) a selective attack on the most connected species, and *B*) through a non selective attack eliminating species randomly. The radii of the circles reflect the number of species contained in each sub-network. The blue circle refers to the most numerous group of species with ecological viability (in the trophic chain there is at least one basal species). The random elimination of species permits the network to stay connected — the small circles are the species we have eliminated and a few other species that become extinct at the same time (*B*) — while for a very small fraction of the elimination of highly connected species, the ecosystem fragments into various sub networks that are disconnected from each other (*A*). The more fragmented the network, the higher the risk of extinction for other species (see text).

at random, each network stays connected, and does not fragment into sub-networks. Most significant is the fact that the extinction rates are very low even when a large number of species have been removed. Something quite different happens when we successively remove the most connected species: secondary extinction rates rise very fast. For example, in the Silwood Park network, the removal of less than 10% of the most connected species (13 of the 154 in existence) causes the disappearance of all the species in the system. In addition, the network fragments into multiple sub-networks disconnected from each other [fig. 3].

The last result might lead one to think that it makes no difference whether there is one sole network with many species or many small sub-networks, each with only a few species, but in general, it does make a difference. The risk of extinction is much higher in the second case. The main reason is what is called the "effect of biological insurance". Greater biodiversity increases the probabilities that an ecosystem will have: 1) species that can respond in different ways to different environmental conditions and disturbances, and 2) functional redundancy, that is, species that are able to replace the function of an extinct species. Moreover, higher levels of biodiversity in a non-fragmented network can maintain the functions of the ecosystem. Thus, in the case of a fragmented network with only a few species, many of those functions may be significantly disturbed (Schulze and Mooney, 1994; Levin, 1999; McCann, 2000).

We can conclude that the most connected species in an ecosystem from a trophic perspective are "keystone species", given that their removal has significant effects on the stability and persistence of the network (Bond, 1994). Some prior studies corroborate the key role played by the most trophically connected species. Like Wilson's observations quoted above related to jaguars and pumas on Barro Colorado Island, Owen-Smith (1987) mentions the effects that the extinction of large herbivores has had on various ecosystems, resulting in a new distribution of vegetarion and the extinction of a large number of species. Omnivorous insects with a wide trophic niche reduce the population fluctuations of all their prey, which, in their absence, fluctuate greatly over time, which can lead to the the extinction of species (Fagan, 1997). In a work in progress on communities of parasitic insects (parasitoids) of other insects, we have observed the stabilizing role of

the most connected species (hyperparasitoids) on the basic resource (the herbivorous insect that produces plant galls). In these communities, the higher the number of connections of the hyperparasitoids, the lower the rate of parasitism on the herbivore. This ensures the persistence of the basic resource and, therefore, that of the entire community. These networks also show small-world type architecture of their connections. From a theoretical standpoint, through the construction of trophic networks on a computer, we have also observed the effects on a community of insects of removing species in terms of secondary extinctions. The primary result is that the removal of the generalist species, which prey on and are preyed upon by other species, leads to a larger number of extinctions of other species.

Given this definition, "keystone species" are determined by their topology in the network, not the trophic position of each species. Therefore, not only large predators should be considered keystone species, but also species at other trophic levels (Bond, 1994). Accordingly, we have found that the keystone species in the trophic networks at Ythan Estuary, Silwood Park and Little Rock Lake belong to different trophic types (Solé and Montoya, 2001). In the network at the Ythan Estuary, keystone species are primarily intermediate species (fish and invertebrate organisms, 60%), some predators (birds, 20%), the remainder being parasites. In the Silwood Park network, the majority of keystone species are herbivores (66%), that may be considered basal species, given that only one plant exists as a resource (*Cytisus scoparius*). The omnivorous hemiptera are also quite significant (26%). In the case of Little Rock Lake, none of the basal species is among the most connected. The most connected species are intermediate species of zooplankton and benthic invertebrates (70%) and predators (like fish, 24%).

### The sixth extinction

Some of the most widespread disturbances of anthropic origin which also have the greatest effect on the loss of biodiversity primarily affect the most connected species in an ecosystem. The process of destruction and fragmentation of habitat is one of the most obvious cases. This process has been seen to be especially harmful for large herbivores and predators with a diet based on a large number of prey (see the example on the disappearance of jaguars and pumas due to the fragmentation of the tropical forests at the beginning of this article). The great majority of species hunted intensely by human throughout the Pleistocene were highly connected species, whose extinction led to changes in the structure of ecosystems and a large number of secondary extinctions (Owen-Smith, 1987). Another type of disturbance, with less clear effects on the most connected species, but with some well-documented examples, is the invasion of exotic species. In some cases, it can also primarily affect the highly connected species within an ecosystem (Drake *et al.*, 1989). Protecting the most connected species, through a minimization of the disturbances that affect them, would guarantee the persistence of the ecosystems of which they form a part.

Many species considered at the greatest risk of extinction are keystone species from a trophic point of view in different ecological systems. Species do not interact randomly within ecosystems: they interact according to be certain complex architecture resulting from ecological succession (with the properties of small worlds and distribu-

| Extinction | Loss of genera (observed) | Loss of species (estimated) |
|---|---|---|
| Late Ordovician (440 Ma) | 60% | 85% |
| Late Devonian (360 Ma) | 57% | 83% |
| Late Permian (250 Ma) | 82% | 95% |
| Late Triassic (210 Ma) | 53% | 80% |
| Late Cretaceous (65 Ma) | 47% | 76% |

**Table 1.** Extinction rates for genera and species in the five mass extinctions during the Phanerozoic (*Ma* stands for millions of years ago; data from Jablonsky, 1991, and Solé and Newman, 2001). Estimates for the extinction of genera come directly from the analysis of the fossil record, while the loss of species is inferred from a technique called *inverse rarefaction*, widely used in palaeontology.

tions of potential connections among species). This architecture is shared by other biological systems (including social systems) and humans seem to have imitated it (consciously?) in the design of multiple technological systems. This structure provided great homeostasis to ecosystems in the face of random foreseeable disturbances that can provoke the random disappearance of some species. Given this architecture, random disturbances will primarily provoke the loss of less connected species, which will generally have little impact on the ecosystem. This is what seems to have happened mainly over the course of evolution: the extinction of species has had a very large random component, as demonstrated by extinction patterns deduced from the fossil record, which did not favour or harm specific species or groups of species (Raup, 1991; Solé and Goodwin, 2001). However, there were also five mass extinctions where the loss of biodiversity of families and genera was huge (Solé and Newman, 2001) [Table 1]. The origin of these mass extinctions could be some extraordinary agent, such as the fall of a large meteorite or intense volcanic activity, but in some cases it is not necessary to turn to these catastrophic external events to explain the existence of a large extinction. A small disturbance could have effected primarily keystone species (the most connected ones, for example), serving as a catalyst for an entire series of extinction cascades through the network of interactions in ecosystems, resulting in high extinction rates inferred from the fossil record (Solé *et al.*, 1997).

An increasing number of studies show that the biosphere is immersed in a new mass extinction (Leakey and Lewin, 1997). In this case, the cause is clearly internal: disturbances of anthropic origin that are essentially unpredictable for the ecosystems involved, many of which affect keystone species. Current estimates of extinction rates, even the most optimistic, prove the devastating magnitude of this process. All these estimates are based on species-area relations combined with estimates of the predictable reductions that the planet's habitats will undergo (May *et al.*, 1995). A recent compilation of several field studies shows that in trophic networks of different types, extinction cascades are taking place. A drop in the population size of a species, or its extinction, leads to variations in the size of populations of other species within the trophic network which, in many cases, also leads to their extinction, and this continues with more and more secondary extinctions. The workings of this domino effect are often caused by alterations of human origin (Pace *et al.*, 1999). A consideration of secondary extinctions and other indirect effects could worsen the outlook of a loss of the biodiversity and functionality of ecosystems, increasing current estimates of extinction rates.

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## Climate change. Sustainability in networks

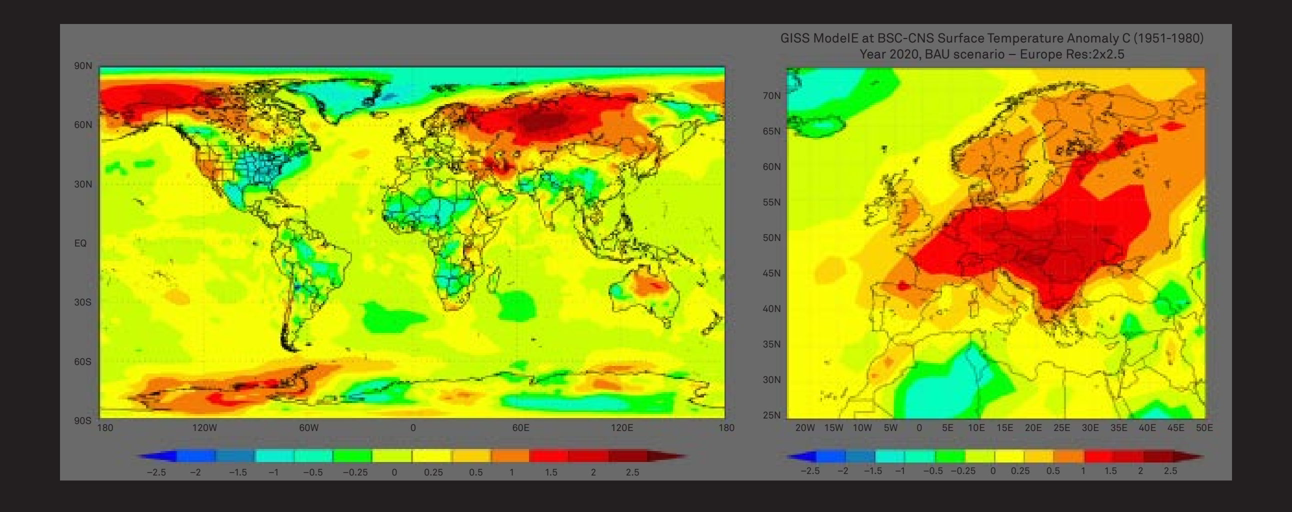
José María Baldasano

**The current climate change is serving to activate our need to learn, to increase our knowledge about our planet, the Earth, about the planet that enabled the generation of what we call "life" and the very existence of our species, the human species. Broadening our knowledge about it is forcing us to move from a static concept to a dynamic understanding of the matter, through an interdisciplinary fabric of processes in networks.**

**Climate change functions as a network-- through forcing mechanisms with intertwined relations, many in opposing, complementary and balancing directions — and that understanding brings us to a new complex perspective. As a result, we know today that periods of drought or rain in the Mediterranean depend on the relationship of atmospheric pressure between the Azores Islands and the Arctic region, just as phenomena like El Niño affect the entire planet. Therefore, we are confronted with a situation in which the processes of climatic forcing could collude to increase global warming at an accelerated pace, overcoming certain thresholds, and with uncertainty as to where the following phase would be headed.**

**Out of the biosphere, the "anthroposphere" has emerged, where socio-economic and energy interests in a framework of "complete globalization are taking the climatic system past thresholds" of no return. Among climate scientists, the most accepted opinion is that it will not be long before significant changes in the climate system are noticed. They will be indicators like current measurements and observations and also those pointed out by global models, which use super-computation to provide forecasts for the future.**

Long-time vested interests have never had any interest in losing their privileges but society does not seem willing to modify its habits and inertias either. However, we need an urgent process of change, of modification, toward a true sustainability that must start immediately. And we are not only talking about improving optimization levels of our current system. We are referring to a paradigm shift based on low consumption strategies and sustainable technologies. And that can only work through international cooperation processes built on models and processes in networks. Today, more than ever before, we need a cooperative global vision.



## The large-scale organization of chemical reaction networks in astrophysics

Adreea Munteanu

Ricard Solé

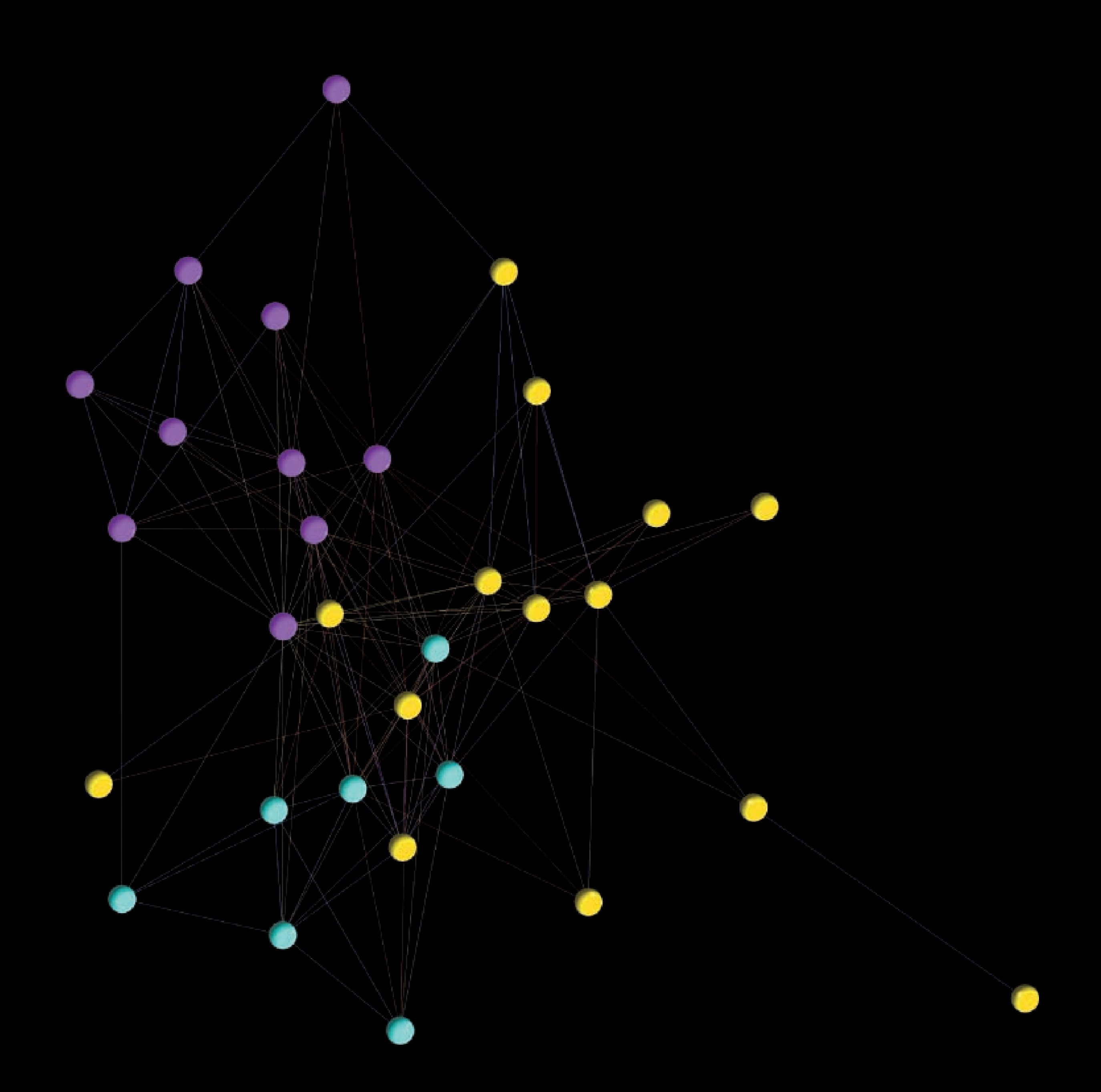
**The large-scale organization of complex networks, both natural and artificial, has shown the existence of highly heterogeneous patterns of organization. Such patterns typically involve scale-free degree distributions and small world, modular architectures. One example is provided by chemical reaction networks, such as the metabolic pathways. The chemical reactions of the Earth's atmosphere have also been shown to give rise to a scale-free network. Here we present novel data analysis on the structure of several astrophysical networks including the chemistry of the planetary atmospheres and the interstellar medium. Our work reveals that Earth's atmosphere displays a hierarchical organization, close to the one observed in cellular webs. Instead, the other astrophysical reaction networks reveal a much simpler pattern consistent with an equilibrium state. The implications for large-scale regulation of the planetary dynamics are outlined.**

**The interstellar medium (ISM) – gas and micron-sized dust particles between the stars – is the raw material for the formation of future generations of stars which may develop planetary systems like our own. Astronomical observations of interstellar and circumstellar regions have lead to the identification of well over one hundred different molecules, most of them being organic in nature.[1] Motivated by these discoveries, astrochemistry – the chemistry of the interstellar gas – has developed into**

an active research area of astrophysics and detailed chemical models can now be constructed which reconstruct the history and role of the ISM in the evolutionary cycle of the galaxy. Crucial to modelling chemical kinetics in the interstellar medium, the UMIST kinetic database[2] consists in the chemical reactions relevant to astrochemistry. In view of the increasing data on the chemical composition of the solar system's planets from latest planetary missions, there is growing interest in the astrophysical community for modelling the weather and atmospheric chemistry of the neighboring planets. Such modelling provided extensive chemical reaction networks (CRN)[3] that expect confirmation from future planetary missions and further modelling. Using the general approach of complex networks[4] we explore here the large-scale topology of the chemical networks associated with the interstellar medium and planetary atmospheres. As will be shown, two basic types of networks are found, being associated with the presence or absence of life.

Within cellular networks, metabolic pathways are one of the most relevant components of life.[5] Such networks are defined at the microscopic, cell-level scale, whereas those considered in our study deal with vast spatial scales. Moreover, cellular networks result from biological evolution, whereas the CRNs studied here are generated from mechanisms that seem to strongly depart from this scenario, although natural selection seems to be a key mechanism for the evolution of Earth's atmosphere.[6] Other CRNs have single-scaled or broad-scale structure. The analysis of network fragility under node removal revealed a high degree of robustness, particularly in relation with Earth's CRN. This (topological) robustness suggests that the overall patterns reported here should be expected to remain invariant while incorporating new chemical species confirmed by future research.





Our analysis shows that, together with a broad degree distribution, the CRN of our planet is also rich in correlations. This is particularly remarkable in terms of the presence of a well-defined hierarchical organization, as shown by its modular, nested architecture. What is the origin of such difference? One clear candidate is the strong, nonlinear coupling between atmosphere and biosphere. As pointed out by Lovelock,[7,8] the atmospheric chemical composition and its departure from a near-equilibrium state are consistent with the presence of life on our planet. Similarly, our analysis shows that the topological organization of Earth's atmosphere displays the hierarchical patterns observed in other living structures. In this context, it is generally accepted that our planet is able to self-regulate its climate and keep a chemically unstable atmosphere constant and appropriate for life.[9] Well-defined cycles can be identified and regulation works over a wide range of conditions. These are all characteristics of a metabolism.[10]

The dynamics and composition of the atmosphere of a given planet is a consequence of both dynamical and historical constraints. Physical factors strongly influence the final pattern at the global scale. But not less important seems the role played by historical contingencies and histeretic processes, which can irreversibly modify a planet's climate. Earth, Venus and Mars all had water soon after their formation 4.5 billion years ago. Venus experienced a global runaway greenhouse effect about 3 billion to 4 billion years ago. Mars followed a different path towards a runaway cooling. The common pattern of organization of both Mars and Venus CRN confirms that lack of biosphere leads to a simple, equilibrium set of reactions with a well-defined, single-scale topology. Instead, the presence of a mechanism injecting reactive components into the reac-

**tion pool might eventually generate a complex network not unlike the ones seen in living structures at the small scale. Future work should explore the use of kinetic models to test this conjecture.**

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Notes

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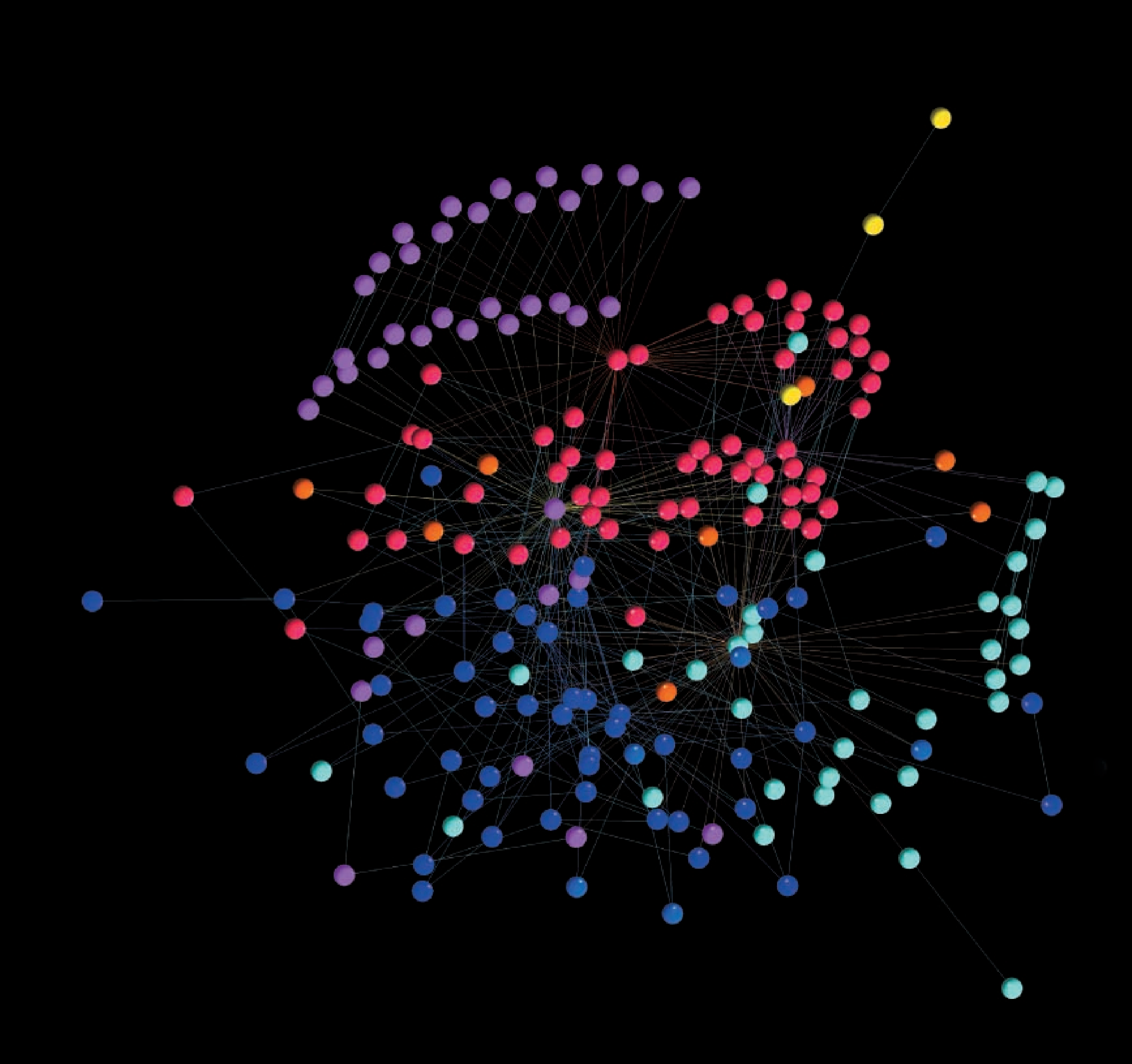
Pp. 312. Earth.

Pp. 313. Molecular structure of Earth.

Pp. 316. Mars.

Pp. 317. Molecular structure of Mars.






the E day

for energy




ALFREDO COLUNGA
***The E Day for Energy***, 2008

Globalization means the possibility to access new markets, suppliers… competition and access to goods all over the planet…This increases the variety of supplies; it means many opportunities for the secondary and tertiary sectors in our economies, as well as in transformation and distribution… State-of-the-art goods circulate faster and faster all over the planet in an increasingly complex net… However, there is a problem. These goods require energy and raw materials… Globalisation also means that the world fossil fuel and raw material reserves are well known. Raw materials which are, or are not, renewable… Oil… food… iron… copper… nickel…

Globalization means that each company in the primary sector has already been allocated one portion of such reserves which will by no means increase… As they know their reserves, the only way for companies to grow will then be… to take over other companies. This generates a rapid concentration of power over resources. And it does not only happen with fossil fuels. But also with the raw materials and the sub-products derived from them…This will eventually lead us to a world where a few will own the essential goods for all. And they will control the prices. The only possibility to invert this tendency is… to find new energy…Such plentiful energy that we come back to competing for its use, and not for owning it. Just as the air we breathe… So plentiful that it allows access to new raw




materials, inaccessible today… Being on this planet… Or others…Probably this plentiful and cheap energy will be fusion. The energy of the sun.

There is a project already in progress to achieve it. It is the ITER PROJECT. However, the ITER project has three problems: technological doubts, insufficient funding, which does not allow for projects to be doubled or accelerated… And the most important one… The funding comes only from technologically developed countries. It does not involve the current energy producers. So the development of this future energy… Is a threat for the current energy producers.

The *E Day for Energy* will be the day when current energy producers and those of the future sit together at the same table… And sign an agreement… The owners of the current energy, fossil energy, will invest in the new energy… And in exchange they will obtain a part in the ownership of the future energy. Enough future energy to be interested in the change… Guaranteeing in the meantime supply and prices in order to perform an organised transition to the new energy era.

The *E Day* is the proposal for a great agreement. A necessary agreement among the energy producers of tomorrow and the energy producers of today… in order to access the world of the future.

**A.C.**

Note: Literal transcription of the work.



KÒNIC THTR
(Rosa Sánchez, Alain Baumann)
***mur.muros / Dystopia #2***, 2007-2008

The various networks we inhabit are interconnected in an incessant dynamic process of mutual influence and interaction. We see this in our everyday lives simply by paying attention to the movements and biological, social, economic and ecological interactions taking place around us. The different scales of these networks and processes that traverse, constitute and structure us range from the macroscopic to the microscopic, from the local to the global and vice versa, creating transversal cuts, hybridizations and interrelations that globalize what is local and localize what is global through flows of all types.

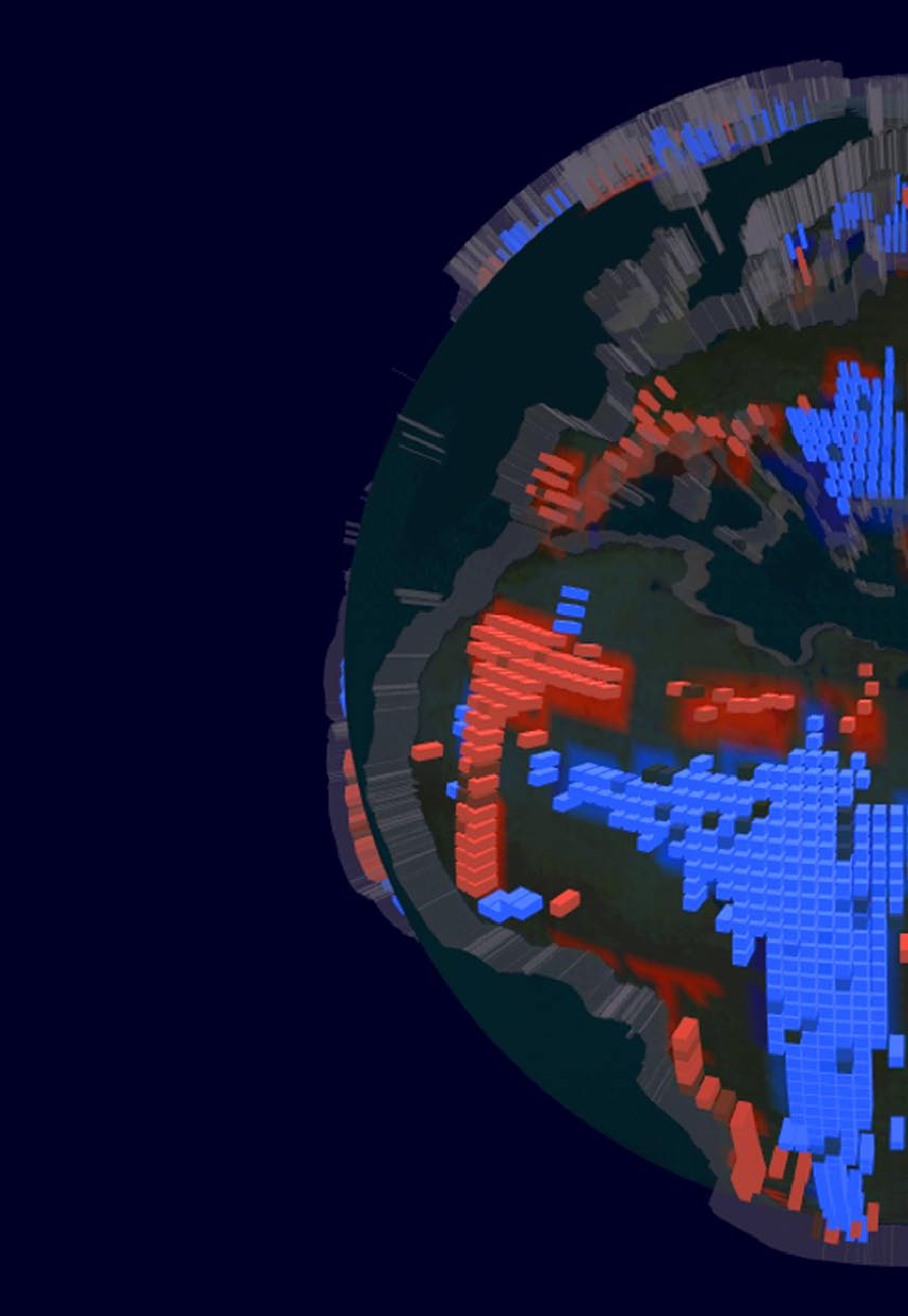
The interactive installation *mur.muros / Distopia #2* by Kònic seeks to portray these flows produced in our globalized society, showing relations between the data referring to the movements of populations at a global level and the sound signals generated by the users in the exhibit hall where the installation is located. An interior space within a cylindrical area includes a visualization and real time sound processing of sounds from the outside the installation.
In this way, the sounds produced by users are captured by various receptors placed at the four cardinal points of the sensitive architecture that defines the installation. These ambient sounds join those generated expressly by users to be processed and converted into




the signals and basic elements that create a digital, evolving, and sensitive environment that constitutes the interior of the cylindrical space. Alluding to the dynamism of Gaia, the *mur.muros / Dystopia #2* installation allows us to see and hear how different sound inputs record movements on the exterior, parallel to data related to population movements in our globalized world.

Gaia, the earth understood as an autopoietic system whose surface is alive, is self-regulating and evolves, moving from equilibrium to chaos, while it is disturbed by human actions as shown by indicators of the global shift of which we are a part. These socio-ecological alterations have a correlation in the migratory movements of those called to move across the world in pursuit of the realization of their stock of utopias. Individuals, peoples, and human groups feel oblige to move to try to achieve the idyllic world generated by various utopian visions of reality. With the help of small screens showing a series of dystopian and utopian images of Europe through its peoples' stories, through *mur.muros / Dystopia #2*, Kònic questions the idea of Europe as a magnet for migratory flows; supposedly, a guarantee of a better world.

**P.A.**







DANIEL CANOGAR
***Other Geologies 9***, 2005

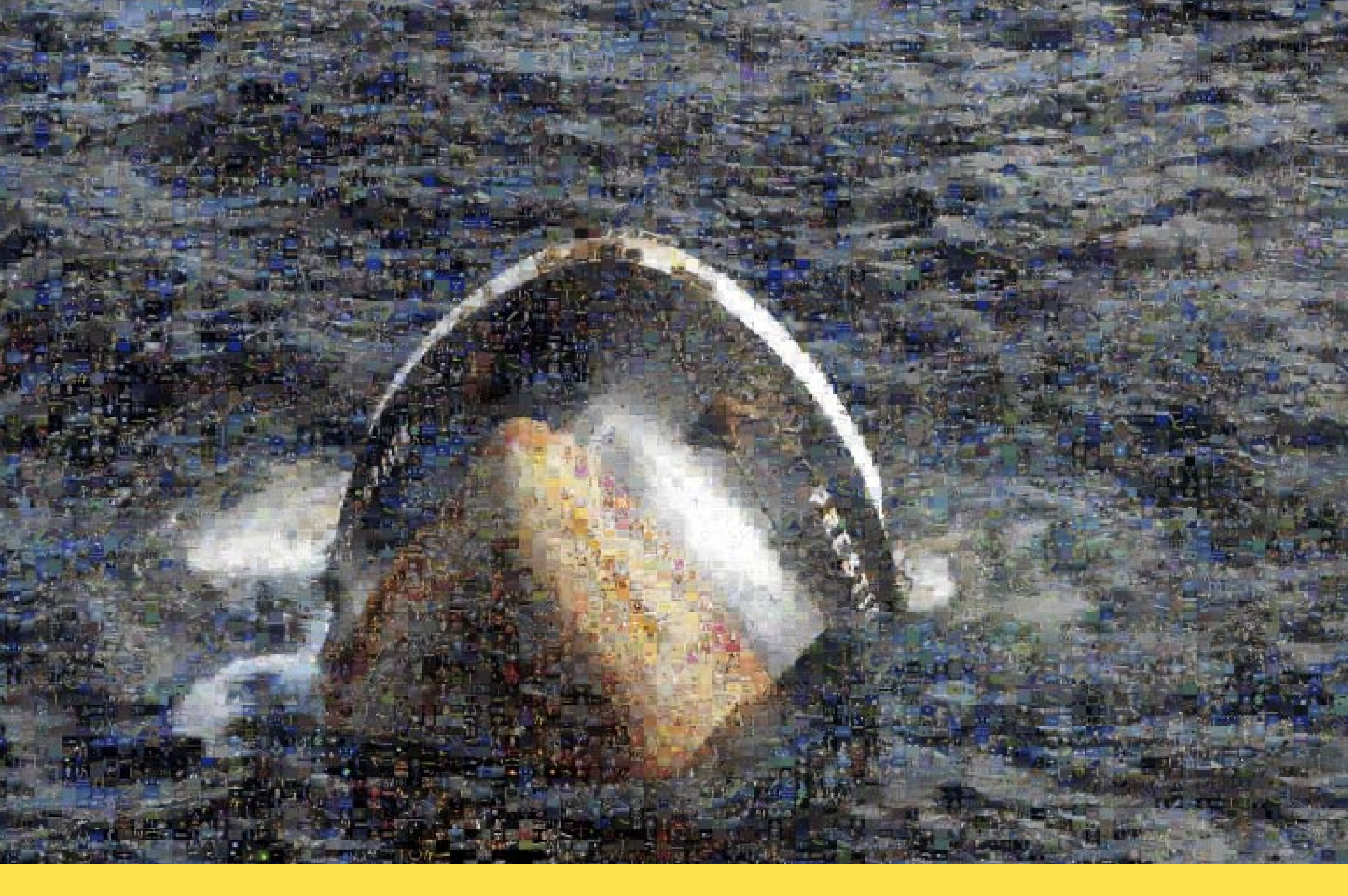
If we omit the consideration of emitter and receiver from the ideal representation of a network, annulling its communicative function, the system of connections will stop being a positive virtual space, becoming simple trash, a tangle of useless cables. A nexus without margins — those margins where life resides, according to Paul Virilio — makes no sense at all. And a nexus without margins, obsolete, discarded cabling, can turn into toxic waste. In perpetual renewal, technological society generates enormous amounts of "e-waste": cables, components, various artifacts made of lead, tin, cadmium, copper, antimony, cobalt, gold, mercury, nickel, zinc, barium and chrome. When the human body is exposed to those elements, its nervous system is irreversibly damaged. Curiously, those abandoned nodes of the technological network, theoretically a product of welfare society, turn against our primordial network — the nervous system — constituting a subtle rebellion of the machine, a favorite subject of science fiction and "cyberpunk" culture. This reflection can be applied to the social realm, comparing an obsolete machine to a human being condemned to ostracism: a man pushed to the edge can also turn against the network, the social system to which he does not belong, but whose existence is known to him. In *Other Geologies 9,* Canogar converts the utopian "network society" into both technological and organic detritus, an amalgamation of cables dotted with lifeless bodies, the corpses



of a postindustrial waste heap. In his evocation of a technological apocalypse, man and machine are intertwined on the same level. The impossibility of communication, the nonexistence of an emitter and a receiver, has turned them into junk, the same junk that ends up affecting our nervous system. The same "junk" that ends up rebelling against the establishment.
**M.Sy.**

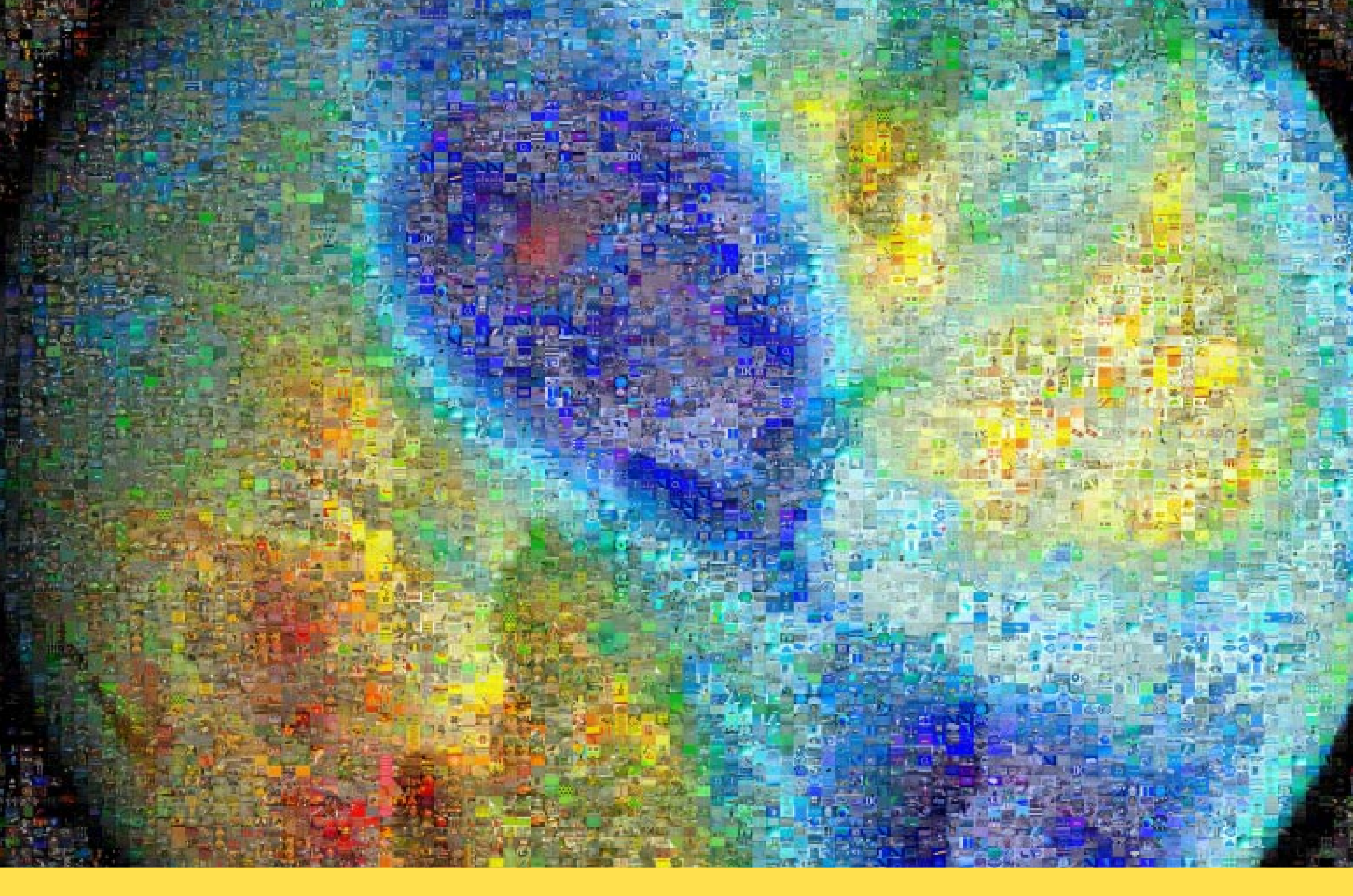






JOAN FONTCUBERTA
***GoogleGram: Ozone***, 2005
***GoogleGram: Prestige***, 2007

Joan Fontcuberta has incorporated play as a determining factor in developing his projects and in their resulting relationship with the public. One must know how to play to approach many of his works. The rules may be unwritten but they are always operative for the viewer. In *GoogleGrams* Fontcuberta produces images composed of other images resulting from an Internet search, through a set of associated terms and what he calls "source images", which arise from the search words. Sometimes, the words serve as a starting point; other times, a preexisting image is used. The process of searching for images and constructing the source image according to the synthesis of those returned by Google is carried out in a sole operation by the software, using the darkest and lightest ones, as well as their predominant chromatic compositions, as pixels that will compose the new version. The procedure takes the fact that all digital images are mosaics to its logical extreme. Pixels are replaced by other images. This apparently simple process, clearly explained in the captions accompanying the image, has fundamental consequences in what could be considered a reflection on the images of synthesis and the information society. The name of the series itself suggests the kaleidoscopic entity of Google, the leading Internet search engine. Google can be seen, then, as a game of chance. When one types in a term, one obtains a number



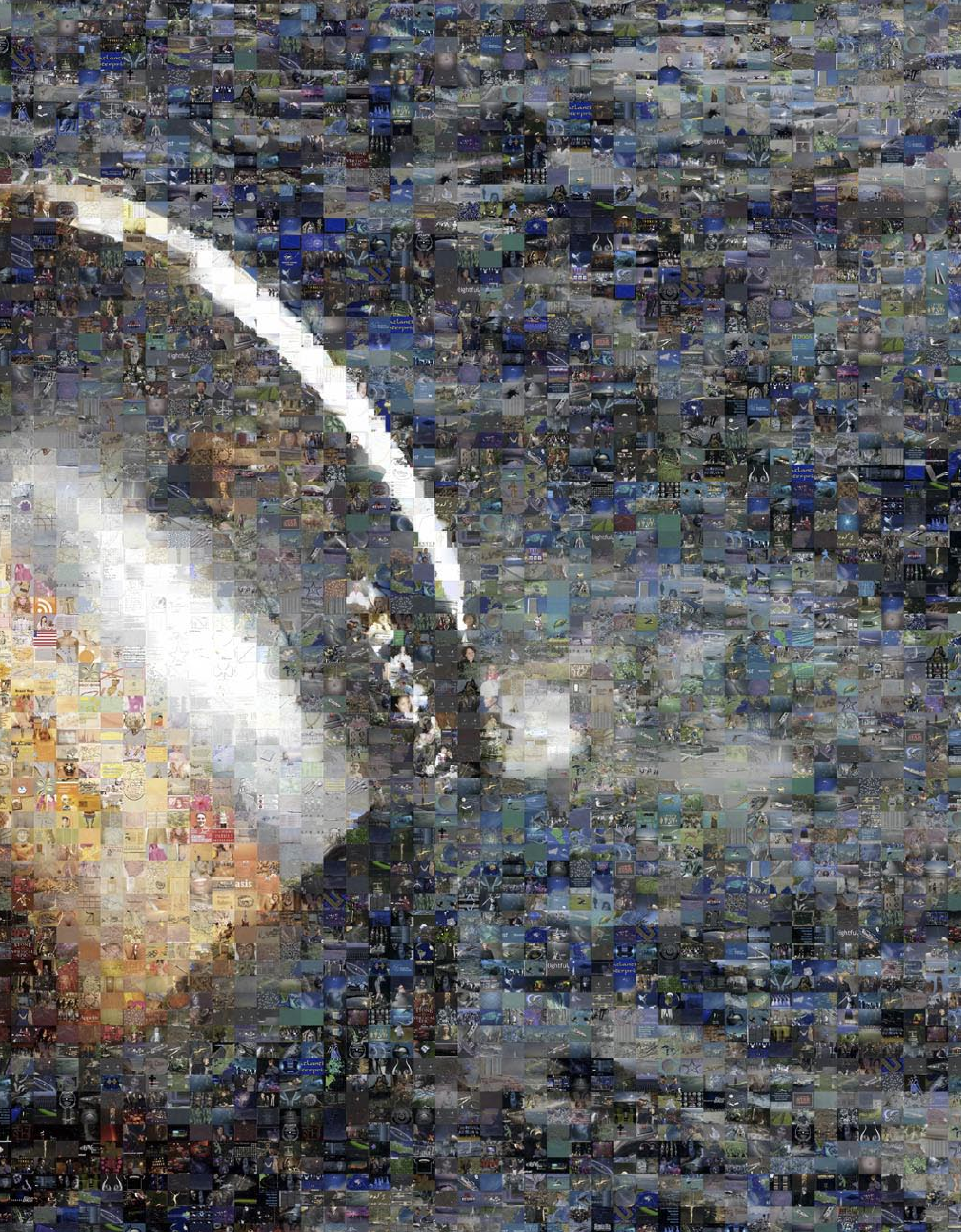
of related responses whose associations are unexpected though related through their reference to the term. Actually, the element of chance is relative. In any case, it is an "objective randomness", perhaps in a strictly Surrealist sense. One almost always gets some response to the term one types into Google. Those results, depending on how general or topical the term is, are usually quite numerous and heterogeneous. At times, the results contain valuable information on the subject of the search but they are always accompanied by others that don't. The informational mechanics of Internet search engines have inaugurated a new associative system that is not exactly random. The semantic movement incorporates a high percentage of significantly imprecise data into the search network and constructs a field of allusions that can lead to a sort of cryptic, repressed semantics of the names carried out in the global Web archives. This scenario is a heterotopy of names and reveals the unsuspected roots of its semantics, prolonged in a linguistic reality based on the contexts of use.

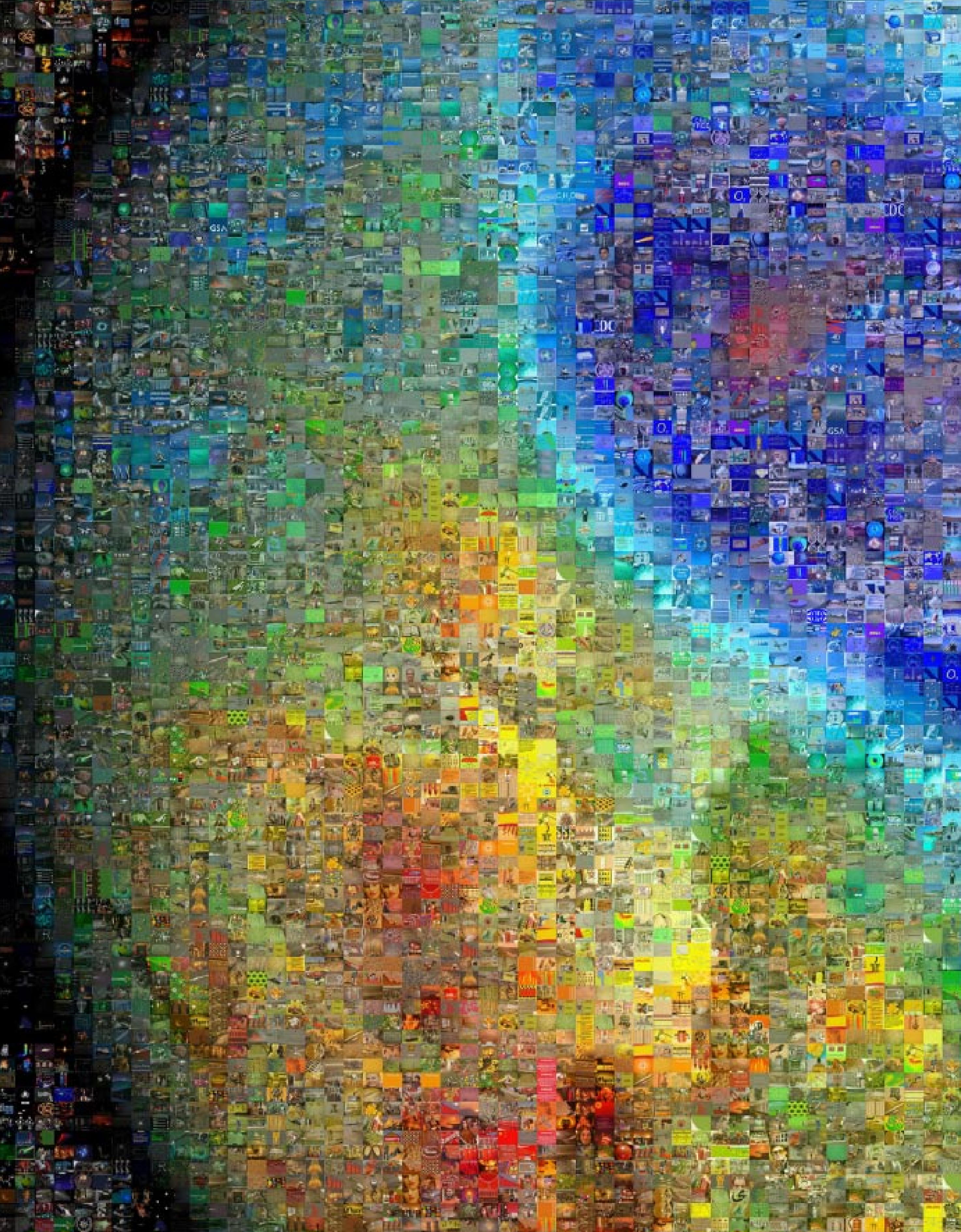
When Fontcuberta brings this phenomenon into the field of images, he adds a new variable and pre-visualizes this associative game, establishing a new visual semantics superimposed on the already complex network of linguistic links. His re-elaboration draws on freeware products — that is, commonly used, free software — to build on the images gathered. It is a visual configuration of the semantic field formed by words on the Web. The game lies in the associative ambiguity of its inclusion scheme. The rules for this game are

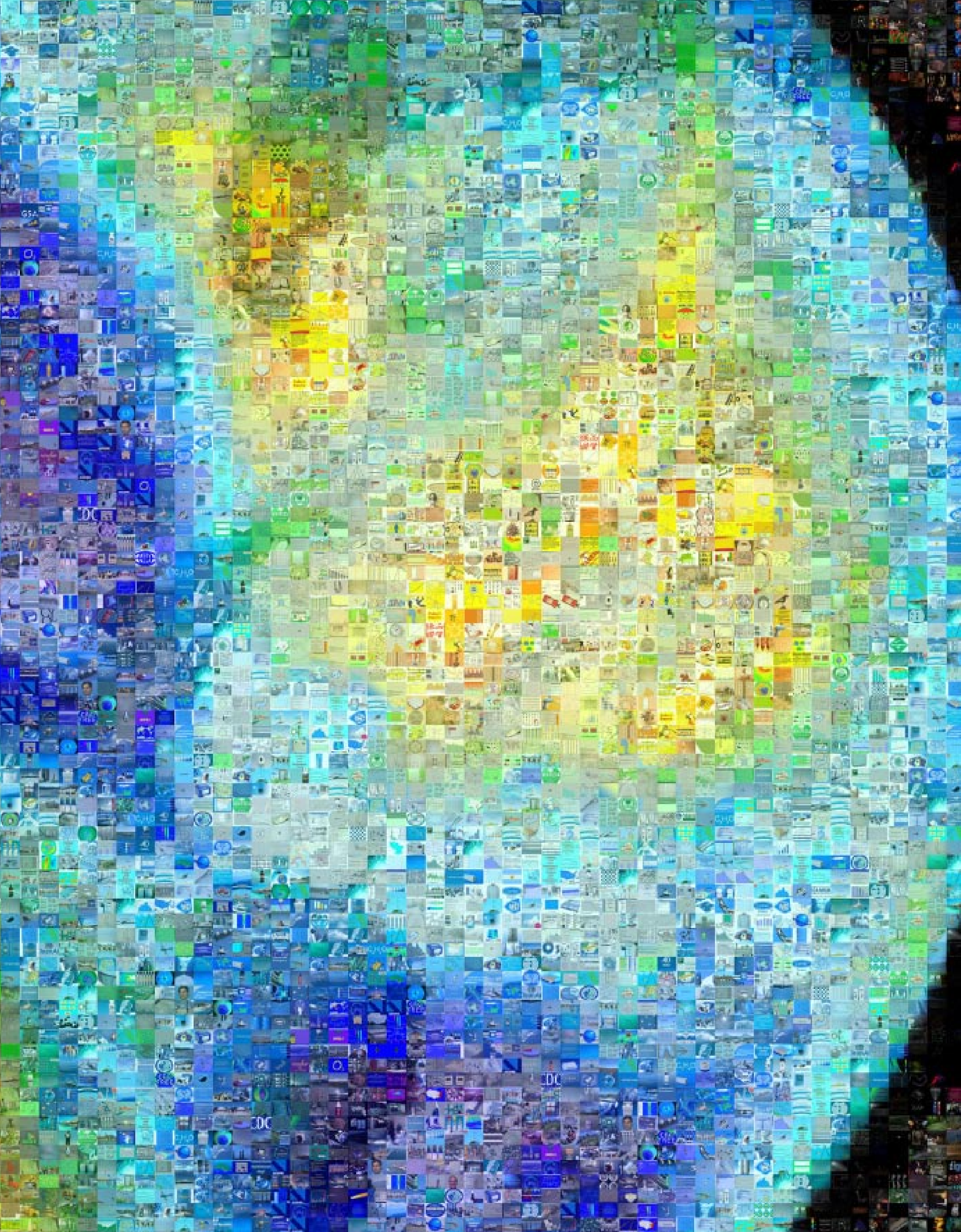


logical, as in other projects by Fontcuberta. They follow a clear pattern like an algorithm, and are presented with a rational respect for the consequences. In those consequences, the world shows a chaotic face and image, and the search becomes intentional and political.
The compositional purpose of the image, using relatively accessible software, is formal while the contents seem to reveal a hidden image. In spite of the simplicity of the procedure, the images obtained surprise us as easily as articles at a fair. Fontcuberta explains the rules of the game in an aseptic, descriptive photo caption. The semantic field activated in our memory by the words suggested by Fontcuberta undergoes the verification process of the vast Internet searches, as well as an awareness of current issues or the historical resonance of terms such as the names of certain oil tankers responsible for major environmental disasters, or the names of chemical compounds that harm the ozone layer. They are all subject to the mirror of the information returned by the most universal and useful search engine. Its massive capacity for access in many languages is demonstrated not only in all the information it can identify but also in the world of images.
**V.R.**









# Internet
# A new *imago mundi*?

Álvaro Bermejo interviews Juan Aranzadi, Agustín Fernández Mallo, Ramón Guardans, Vicente Verdú and Remedios Zafra

Ever since the beginning of humanity, each technological revolution has led to a new worldview. Like the transition from *Homo habilis* to *Homo sapiens,* or from the taming of the horse to the invention of the wheel, the mere widening of the limits of the known world has always shaped an evolutionary space parallel to the expansion of time brought about by the calendars of the first civilizations.

The invention of the oar corresponds to one perception of the horizon, that of the sail to a very different one. Something similar occurs with the distance between the first steam engine and the first internal-combustion engine, or the first microscope invented by Gallileo in 1610 and the space telescope conceived by Edwin Hubble in 1940.

It is no accident that in the era of great discoveries, the course that a visionary named Christopher Columbus charted between two worlds and two times — the Middle Ages and the Renaissance — was accompanied by the spread

of printing after blacksmith Johannes Gutenberg had the idea of adapting winemakers' grape presses.

Quite a bit earlier, around the year 1000, a Chinese craftsman named Bi Sheng had already invented printing with movable type made from porcelain, and, by the seventh century B.C., philosophers like Thales and Anaximander were already positing the idea that the Earth was round. Moreover, it is equally possible that Eric the Red's Vikings trod the verdure of Greenland long before Columbus. But the true change in how our world was perceived arrived with the Genoese navigator and the German printer. Their discoveries brought a cultural change of global proportions, marking a substantial before and after that separates the medieval maps of a flat world from the first representations of our planet as we know it today, thanks to the cosmography of the Renaissance.

The new Renaissance worldview was a revolutionary change of perspective; a leap from the horizontality of the old medieval planispheres to the sphericality that appears in the first maps by Gerardus Mercator. Five centuries later, we face a similar phenomenon. The creation of Internet and all its virtual worlds also seems destined to mark a before and after.

While the horizontality of the Middle Ages turned into the sphericality of the Renaissance, the world defined by the Internet is post-Copernican and post-Euclidian, and thus open to multidimensionality and multi-polarity. And of course, it is equally open to the most radical transversality. Concepts like "network society," "connectivity" and "virtual paradises" circulate on the Internet, crossing all of science's borders and making all membranes of knowledge permeable.

Sure of its many benefits and spurred by its challenges, the Internet operates as a grand global attractor, free of limits and constantly expanding. It would be inexplicable without imagery to reflect its complex plasticity.

But how, and how much, is this network of ungraspable flows changing our societies? In other words, what new *imago mundi* is the nascent network society configuring?

Both questions provoke a reflection based on underlying concepts that are similar in both form and content. There is no better way to consider multi-polarity and transversality, than by analyzing the Internet through a collective, transversal and multidisciplinary consultation that generates its own tissue of networked answers. The tension and connections that arise from such a choral examination — its convergences and divergences — will bring to light the almost indefinable plasticity whose emergence nevertheless expresses the network's transparency, even in its darkest areas.

From this opening perspective, we brought six heterodox thinkers — Juan Aranzadi, Agustín Fernández Mallo, Ramón Guardans, Javier Moscoso, Vicente Verdú y Remedios Zafra — together to discuss nine very open questions. These are their answers.

**1. The literal translation of the word *utopia* ('nowhere') defines a virtual reality. Does the reigning utopia of the Internet and total connectivity appeal to the same imagery as those of Thomas More and Campanella?**

**Verdú.** The utopia that most often appears on the Internet in recent years is the one called infotopia, a term coined by Cass R. Sunstein that refers to the advantage derived from sharing knowledge in the way that was done to create Linux or the Wikipedia. This idea of the superior knowledge of the crowd, rather than the knowledge of genius or of the leading

light is expressed in books such as *The Power of Many*, *The Wisdom of Crowds*, *Smart Mobs* and a few more that were bestsellers in the United States and other English-speaking countries before the crisis hit them. In Spain they have taken root in a few large companies.

**Guardans.** I am a little nervous about the mystification of thinking that extraordinary things are happening right now without our having freed ourselves of humanity's technological arrogance. It is true that today we are playing with the extreme scales of micro and macro, from macroeconomics to molecular biology. And it is certain that those scales that would have been inconceivable in earlier times are now clearly visible. But the "myth" that white males are different, superior and hegemonic as opposed to other "lesser" forms of existence — feminine, or richer in skin pigments — continues to rest on the rather fearful technology of ignorance that runs parallel to a notable pathology associated with trafficking in certitudes. We need new perspectives if we are going to make any sense of the mountains of new data running from bacteria networks to the worldwide flow of resources and waste. New realities demand new narratives.

**Aranzadi.** What you call "the reigning utopia of the Internet and total connectivity" leaves my imagination totally cold. It doesn't waken anything, and it doesn't bring anything to mind; it leaves me completely indifferent. As to the utopias of Thomas More and Campanella — they bored me to death when I read them, and they didn't stimulate my imagination, either. I think I am impervious to utopias.

**Fernández Mallo.** I rather believe that it could be defined as a utopia based on a certain anarchy, understood as a positive movement of unregulated relations that addresses momentary interests and the good faith of participants. In other words, a utopia in all senses of the word. Moreover, I do not believe that total connectivity is a utopia unless it is established in equal terms at all nodes. That is what Michio Kaku — a physics professor at the City University of New York who has catalogued different sorts of impossibilities — calls "type-1 impossibilities." These are situations or artifacts whose occurrence is not impeded by any sort of theoretical or technological impediment.

**Zafra.** Although utopia as speculation about an ideal refers to an imaginary entity, the idea of the net as a utopia refers to something that exists. In that sense, its nowhere "describes" cyberspace, rather than imagining it. Nevertheless, the literal manner in which this alignment takes place on the net does not save it from speculative games about what "it could be" or what inspires it, so in internet we can find equivalencies with, and even the culmination of other political utopias from the past. Every beginning — and the socialization of Internet is more of a beginning than its technical creation was — is the moment for a utopia. In the 1990s we believed that the net would not be shouldered with burdens from the past and that the disembodied aspect of relations established and carried out on a screen would lead us towards the dismantling of the "Other..." Nothing could be farther from the truth. Today the net no longer appears innocent (it never was, but it seemed to be) and in that sense, I believe we

are living a post-utopian moment. Just behind what we most love about the Internet — non-hierarchization, democratization, collective creativity, connectivity, imaginative potential, dematerialization and so on — lies its dark side, the correlation with other forms of hierarchization and inequalities that constantly delay utopia.

**2. Hobbes founded the modern state on the myth of the Leviathan. In your opinion, what would be the two founding myths of modern and post-modern society?**

**V.** The myth is Jacques Attali's so-called hyperdemocracy. A sort of diffuse and relational power, a network society where, in politics, corporations, family and religion, the horizontal takes preference over the vertical and the flatness of low-cost democracy over the luxury of a hierarchy in a manner we thought was long gone.

**G.** Myths are toys, conceptual instruments. Unlike other biological consortia, the human group has invented stories to reproduce ways in which some individuals can dominate others. Information must be freely available and there must be real, collective sharing of the finest tools offered by new levels of knowledge. Right now, we have only partial access to those new levels of knowledge, as well as a stunning inequality of access to resources. Just 2% of the world's population controls 50% of planetary resources. And if we open the scale of exclusivity a little, we continue to have 10% that shares 86% of those resources. That is even worse than the situation during the time of the pharaohs or Marie Antoinette.

We can continue to naively believe in the myths of redeeming progress but tremendous inequalities, forms of hegemony and exploitation continue to arise.

**A.** The foundational myths of modern society? I would say that the main legitimizing (and mystifying) ideology of capitalist society is the liberal theory according to which the invisible hand of the market harmonizes opposing individual interests, along with its corresponding ethic of "private vices, public profits." And that the main legitimizing (and mystifying) ideology of the democratic state is the theory of the social contract in any of its variants (Locke, Rousseau, etcetera).

I have no idea what "post-modern society" might be, nor what its "founding myths" could be, either.

**FM.** Modern society's founding myth would be precisely that of the utopia of ongoing progress through which humanity would reach a perfect state. It is the utopia of scientific progress that emanates from Newton's deterministic mechanics. Just as there was an absolute time, there had to be an absolute end or goal, a teleology. We are talking about a correlate of Christian time: the chosen people advance in a linear fashion from creation to end (apocalypse).

The founding myth of postmodernism would be the possibility of negating modern utopias and the existence of a perpetual present that annuls history as we knew it. Or a cyclical time more like the idea of time in Hellenistic culture, where circular movement represented perfection. Second, the physical model associated with this myth would be that of "complex systems." Third, this leads to the assumption of a certain type of cultural relativism.

Somehow, by negating any utopia, postmodernism becomes the only "utopia" until now to actually be under way.

All of this only applies in the framework of Western cultures: the words modernity and postmodernity have no meaning whatsoever outside that context; they are not even defined.

**Z.** I believe that the greatest myth of modern society was its own "inspiring idea" of enlightened myths: the neutrality of reason, its power and impartiality (even when it was used to conveniently irrationalize someone). On the other hand, postmodern society seems to be founded on the discovery of this manipulation and the consequential revelation of its bias and partiality. Seeking to overcome the hegemonic and exclusive past of those who took control of reason, it now depends on the plurality of stories and its appearance of horizontality (another myth, although it works for us as long as we use it). As I see it, an illustrative image of those myths could be the "scientist" Frankenstein, as a reflection of modernity's drift, with the imperfect, partial and hybrid cyborg as the postmodern myth.

**3. Following the eclipse of the century of lights, the enlightenment's myths began to show their dark and terrifying side. From then on, from *Frankenstein* to *Fahrenheit 451,* modern reason has not ceased to be threatened by the overflowing of its principles. As you see it, what are the weakest — and strongest — points of network society?**

**V.** The weakest is its difficulty in producing truth and trust. The net tends toward mendacity and crime, falsehood, lack of rigour, and most of all, rumour. Its strongest point is its production of interpersonal communication. What most matters to people are people and communications technologies have been such a spectacular success because they respond to a latent demand, a desire to relate that opposes the prison of hyperindividualism that reigned in the richest countries towards the end of the 20th century.

**G.** Ever since the Enlightenment, in this part of the world we are suffering a dislocation of the forms of knowledge whereby pleasure is removed and replaced by the invention of Science with a capital "S." What amuses and enlightens us — in a word, the humanities — is set aside and assigned no practical or political use or executive power. And this continues to be the case today. In our country the basic objective of teaching has for many years been the reproduction of repugnance towards mathematics and an aversion to science. Fear continues to be an enormously profitable industry, promoting fear of thinking and enjoyment of acritical certainties.

**A.** Regardless of the changes that may have taken place in the hegemonic ideology of "modern" societies, I believe that the "overflowing of principles" in the 20th century (totalitarianism in its Nazi or Stalinist versions: Auschwitz and the Gulags) is more of a continuation than a break with the political Terror of the French Revolution, the horrors of the Industrial Revolution, the destruction of society by the market, and the domination, exploitation and extermination of peoples by European colonialism in the 19th century.

**FM.** It depends on what you expect of network society. In other words, it depends

on the degree of ingenuousness with which each person approaches this matter. To me, a skeptic by nature, it has all the weaknesses and strengths of any sort of society because I expect no more of it that of any group deemed a society. Theoretically, network society, unlike the hierarchical tree model, is horizontal, rhizomatic and lacking in hierarchies. In practice, that is not really the case because it is topologically designed as a network of inverse power, meaning that some nodes are very connected while others are hardly connected at all. It is enough to cut the links to very connected nodes in order to provoke a partial system failure. That means its topology is not tree-form, but almost so — a middle ground that is no more than an illusion that allows us to keep playing.

**Z.** From my viewpoint, this overflowing of modern reason is equally valid as a description of the weaknesses of network society. I believe that everything that makes subjectivity and collectivity possible on the Internet runs the risk of being overwhelmed by its own excess. To a large degree, it is sold to us in terms of its new possibilities of emancipation, connectivity, access and communication by turning all of us into producers, distributors and autonomous agents of knowledge while other ways of organizing the visibility, prestige and value of what we are doing is worked out. At the same time, the excess of information inevitably leads to new forms of censorship — what Virilio called censorship by "saturation" of information and data. This drift favors new forms of domination hidden behind what is "new" and falsely democratic. The on-line world reiterates identitary clichés and favours the lack of time to reflect. In other words, it repeats much of what we criticize in the offline world. The speed offered by the media tends to reinforce ideas that were already present among us, taking for granted that what is being communicated does not need to be questioned. Nevertheless, while this is a characteristic of mass media, it is true that it is much more visible on television while on the Internet we can confront it and intervene.

**4. The screens of *Fahrenheit 451* literally interact with the inhabitants of houses in that future world. Can connectivity be a tool for social control designed by the new "masters of the air" not so much to open its networks to utopia as to have everything well and truly under control?**

**V.** Opacity could be the paradox of transparency. Baudrillard's "total screen" would be the metaphor of everything exposed but simultaneously veiled by an excess of light. Pornography has that: everything is visible, and one sees so much that it no longer matters. We wind up feeling that there is nothing to see. The Internet reproduces that contradiction when it offers itself as a source of hyper-information so blinding that it leaves us in the dark.

**G.** Social control changes but it is difficult to attempt to evaluate those changes in absolute terms: it used to be the neighbour or the parish priest, and now it is a webcam. We continue to be surveilled. And there is a huge lie about digital "connectivity" that I find very amusing, as if it were this century's greatest invention. Our hormones come from genetic and metabolic connections that date back billions of years in an unbroken process, and

that connectivity is barely mentioned. Cable connections are child's play compared to that millenarion biological connectivity that permits an immune system like ours. Even if we are not aware of it, we have an extremely complex defence system that can defeat an enemy totally unknown to the individual when it suddenly appears, simply because some forebear from thousands of years ago passed down a "crib" with the keys to deactivate it from within. That is fascinating, and that is what should be studied.

**A.** I am extremely clumsy and inefficient in my use of the Internet and of the various devices that have invaded my life in the last two decades at the behest of the institution where I work — the university. I do not know whether they are the cause or the effect, but I loathe them to different degrees: I intensely hate cell phones and e-mail, which constantly violate my domestic space, making isolation impossible and keeping me from enjoying my solitude. They locate, connect, surveil, summon and bother persons and institutions that generally want only to flee from them. Moreover, I try to live slowly, appreciating tranquil reflection, and my brain only works well with a relatively limited amount of information.

**FM.** I do not believe in conspiracy theories but rather in well-defined powers that do not want certain relations to take place. But that seems logical to me; the world is full of madmen and what binds us also protects us. It is all a matter of negotiating the balance between freedom and surveillance on the Internet.

**Z.** The transparency of machines from the modern era (which allows one to see their insides and understand how they work, thus facilitating their reconstruction) has given way to the contemporary digital interface (a screen that does not allow access to the inside of the device). This certainly propitiates the mystery of the "other side" and the opacity of the web, challenging us to live with the feeling that there is a permanent all-seeing eye on the other side. Personally, I am anxious about the idea that everything might not only be being watched, but also recorded; it is difficult for us to live with ourselves. I am not sure whether we are getting used to the sensation of living under the panopticon, or whether the gaze we just assume is behind webcams, mobile devices, public buildings and satellites continues to incite us in a most Foucaultian manner to spy on ourselves. Of course connectivity is correlative with the invasion of privacy, but we must not forget that what we call the "masters of the air" serve to keep us alert (we need "the barbarians," as Kavafis put it). Every utopia demands the localization of menace, the possibility of addressing power, assigning it a name and face, be it that of a monster, a king or an adolescent prankster, with a tie or a leather armchair from which to surveil us like Big Brother... or simply as a lord of the air.

**5. The myth of "totally connected life" has coincided with the twilight of ideologies, but also with the reemergence of nationalisms of every stripe and the blossoming of the most diverse self-involved ethics. Are there too many coincidences in this hall of mirrors?**

**V.** Nationalism strikes me as an excrescence from the past. Our much-reviled period provokes a melancholy for the past, but it would

be ridiculous or picturesque to ride to the movies on the back of a mule, and entertaining nationalist pretensions, learning to speak like one's ancestors, and so on, is equally grotesque.

**G.** I still do not really understand what the term ideology refers to nowadays. Marxism? It has a great tradition in the academic world, but in practice it has almost always been ruined because the party becomes a church, with its dogma and terror. Some theorists — Antonio Gramsci and Rosa Luxemburg, for example — continue to be useful for analyzing contemporary social tensions. I see danger in the metaphysical rascalry based on theology and dogma, or the identitary intoxication that underlies nationalism. At any rate, the problem is not so much a question of ideological systems as of the reproduction of class domination and unequal access to resources and dominant discourse.

**A.** I do not really understand the phrase, "totally connected life" but I can tell you that every day I feel greater appreciation for face-to-face, body-to-body human relations, for the selective proximity of freely chosen individuals, always modulated and offset by periods of greater distance. And I prefer oral communication to written. In other words, I am horrified by the idea of "total connectivity" and am not at all attracted to chatrooms, forums, blogs and other forms of virtual massage that apparently brings such pleasure to so many people.

**FM.** Nationalisms are a nostalgic reaction to modernity in the face of total connection. Nationalism is founded on two myths: the previously mentioned myth of modernity — the existence of lineal time and of a chosen and uncontaminated people moving forward towards their own destiny — and the myth of reversible, postmodern time, that is, the possibility of moving backwards towards the point of origin. The combination of those two opposing movements annuls both, offering the illusion of zero velocity. That is not the same as the postmodern case, which denies history because of circular movement, rather than because of zero velocity. In other words, in each of its circular turns or loops, the postmodern system feeds back on itself and thus learns, as is typical of the complex systems mentioned above. That, then, is total connectivity, the illusion of a loop or system of loops that feeds back synergetically.

**Z.** It seems to me that both movements (total connection and nationalism) are part of the same stage. Each acts as a background to the other, growing stronger in an effort to almost homeostatically counteract the sense of loss that the global provokes in the local. Thus, the rise of the virtual world and of total connection coincides with a moment of intense defense of local identities and nationalisms. Curiously, the virtual world also coincides with the reemergence of materialist viewpoints, both ecological ones and an unstoppable and growing body cult. This not only occurs outside the virtual world, but also as an instrumentation of the on-line medium. Such self-absorbed ethics are an inevitable response to total connectivity's overdose of dispersion and to the consequent feeling that the subject's roots and stories are being lost.

**6. Walter Benjamin related the root of all contemporary myths to the civilization of the image.**

**Have images replaced words in the realm of the collective unconscious?**

**V.** Book culture is in retreat. The greater part of knowledge is not found in books but on screens or through travel or multiple superficial and ephemeral relations. Culture is audiovisual, emotive, sensational and sensationalist. Book knowledge requires concentration, the working out of meanings, and time. Our period is the opposite: it skates over a mosaic in order to grasp a highly varied totality. In-depth understanding is the same as strengthening one point whereas understanding the world on screen requires a maximum of mobility. Rather than the vertical gaze of reading, this is the panoramic view of audiovisual space.

**G.** Images are words and words are images. In front of me is a book of almost a thousand pages that describes how Chinese technical illustrations transmit knowledge. Writing cultures have a fantastic precedent in biological networks, which also establish their own communications flows. Societies and individuals build on their past and respond in their own frames of reference as a function of biologically or socially acquired skills.

**A.** Actually, the different systems of writing, especially alphabetic writing, are what led to this substitution. The written word is a grapheme, an image that reproduces the phonemes of the spoken word so that, instead of being audible, it becomes visible.

I find Guy Debord and the Situationists' old diagnosis more adequate than Benjamin's categorization for those of us living in a society of spectacle, that is, a capitalist society in which "capital has reached such a degree of accumulation that it becomes image". From that perspective, "the web" would simply be one more avatar of market fetishism.

**FM.** The word has lost its hegemony over the image. In fact, the novel and poetry are dead genres in the sense that they no longer have any impact on society. That is not the case with cinema. It so happens that seeing and looking are much more natural and innate acts than reading. In other words, everyone is born seeing, but not reading. Words are a sort of algebra, a very complex and tremendously abstract cerebral construct that is not at all obvious. The hegemony of the image is totally in keeping with postmodernity for one reason: the language (words) of Western cultures is based on linear time; our sentences are going somewhere. If, as postmodernity would have it, we are only moving in circles, then we are no longer going anywhere, so it is more logical to represent things with images, which lack the vectorial pulse of narration. An image is one unto itself and simultaneous; in essence, it goes nowhere, constituting a form of representation that a classic thinker would even consider primitivistic — like cave paintings. This combines with Ur-pop, as theorized by Eloy Fernández Porta in his book *Homo Sampler* (time and consumption in the "afterpop" era).

**Z.** I do not think words can be replaced, but they can be eclipsed to the point that this would define as singularly superficial an epoch as ours. This is clearly a criticism, not of images, which are mere vehicles, but of their use as instruments for neutralizing thought. The velocity imposed by moving images reinforces a less reflexive time (Bourdieu), accentuating a sense of

impermanence, reinforcing the symbolic and the past — all that does not require reflection because it is already inside us. Still, I believe that web images are different than images in other media. As compensation, digital images finally make all of us producers, or "artists". Their malleability accentuates their character as process rather than as essence, placing us in a new symbolic framework in which everything is malleable (including ourselves in our virtual representations).

**7. If the knowledge that circulates on the Internet is truly free, fragmented and contradictory, what sort of *imago mundi* can be built on that basis? Is there a new *Discourse on Method,* a keystone, a plan, at least a "theory"?**

**V.** There is no plan, no long-term project, no predetermined goal. As in videogames, each adventure or sudden change of fortune generates the next. Interaction continuously alters the path and its goal. There is no *imago mundi*. The world merges with its own realization and the uncertainty of the process.

**G.** There are nine million individuals watching the world go by, each with his or her own viewpoint, all of which are legitimate. There is no central point from which the world is better understood. Identitary simplifications are as ridiculous as discourses that attribute a sense of direction to globalization, with captains at the helm.

**A.** I suppose "the web" will have led innumerable enlightened individuals to draw up new discourses of method and find new philosophical stones, but I have no idea if it has contributed to the increase or decrease of the number of true seers, prophets and preachers. My impression is that human foolishness neither grows nor shrinks, it simply transforms.

**FM.** We could look at this from two viewpoints. In the first, Baudrillard's image from *The Perfect Crime* would remain in force, implying that the perfect crime has been committed: nothing is outside the market, which occupies everything. Even the most anti-market movement belongs to the market. From the other viewpoint, I believe that there is a reasonably complete theory of knowledge as such. It is just that your question is already loaded with modern paradigms — for example: "discourse of method" or "end". Today, what is fragmented is no longer necessarily contradictory, it is no longer "informative noise", nor even spam. Many of us are actually working with that spam, aesthetically redefining it. In principle, knowledge on the web, as in any "organism", is self-regulated to a reasonable extent.

**Z.** We inherited this need to cling to methods, keys and theoretical bases that calm us. But maybe it is time to defend the value of the imperfect and the contradictory. Our relations, knowledge, art and lives are filled with contradictions. Obviously, theories and discourses of method seek to clarify things and help us live, but to a large degree, they homogenize and simplify things. It is not a matter of defending an entropy in which we would be paralyzed by uncertainty, but rather to recover the productive value of the fragmentary and contradictory, recognizing the new challenges and new responsibilities of the connected multitude (collective creativity) without waiting for an *imago mundi* to be imposed on us by others

or filtered down from elitist utopias. Still, in keeping with the contradictions of our time, we continue speaking of teleogical meanings and theories. We may never resolve this question, but, like Lévi-Strauss's sense of myth, we will strengthen the "extremely important" feeling that we can understand the world, or that we actually do understand it.

**8. The virtual forum of the web world presents at least two very unequal sides: that of progressively more opulent societies and that of perpetually impoverished ones. From the disquieting Third World — not the seductive "third culture" — Aminata Traoré asks: "connected to what?" What would your answer be?**

**V.** It is the age-old question of how to be happy in the midst of so much misfortune. How can we think when so many people cannot even eat? How can we celebrate connection when so many people have no shelter? The world is headed in a more positive direction than it would seem. For the first time in history an effective globalization is being built, a planetary sense of humanity.

**G.** Of course we are connected: the whole planet has had access to the radioactive confetti scattered by bombs, tests and accidents ever since 1945. Greater access to the Internet certainly doesn't mean anyone is less subordinated than before. I very much agree with Amartya Sen's observation that singular identities, the construction of submissive, absolute and central certainties, are forms of martial arts intended to pit some against others. It is important to uninvent all this identitary and nationalist foolishness. The self is porous; the world, a distributed process with a long memory.

**FM.** I believe that the "virtual forum of the web world" is only applicable to the first world. Impoverished societies have no access to that virtual forum. They are busy surviving while we are ever more opulent, which creates growing and accelerating grievance. It is as though we had suddenly created a zone of "dark energy" between us and them, an energy that accelerates our first universe, leaving the third universe behind.

**Z.** I believe that the West's sense of guilt is a dangerous weapon that generates a great deal of paralysis as well as hypocrisy. Discourse is global, but connection is only for the privileged. Moreover, the context in which this question is formulated is already part of the answer to inequality, because what is art's answer? What is the artists' answer? What does the present text do to responsibly answer this question from the side of opulence? We speak of globalization and the web because we are all connected but in a profoundly asymmetrical fashion with different senses of progress. "Connected to what?" asks Traoré… And from our heated and connected houses we can formulate the desire to connect to a different globalization, imagining new utopias that may even motivate us to work for them. But Traoré undoubtedly knows the best answer to that question, and she does not need us to think for her: at any rate, we could think with her, as she says, "let us understand, first."

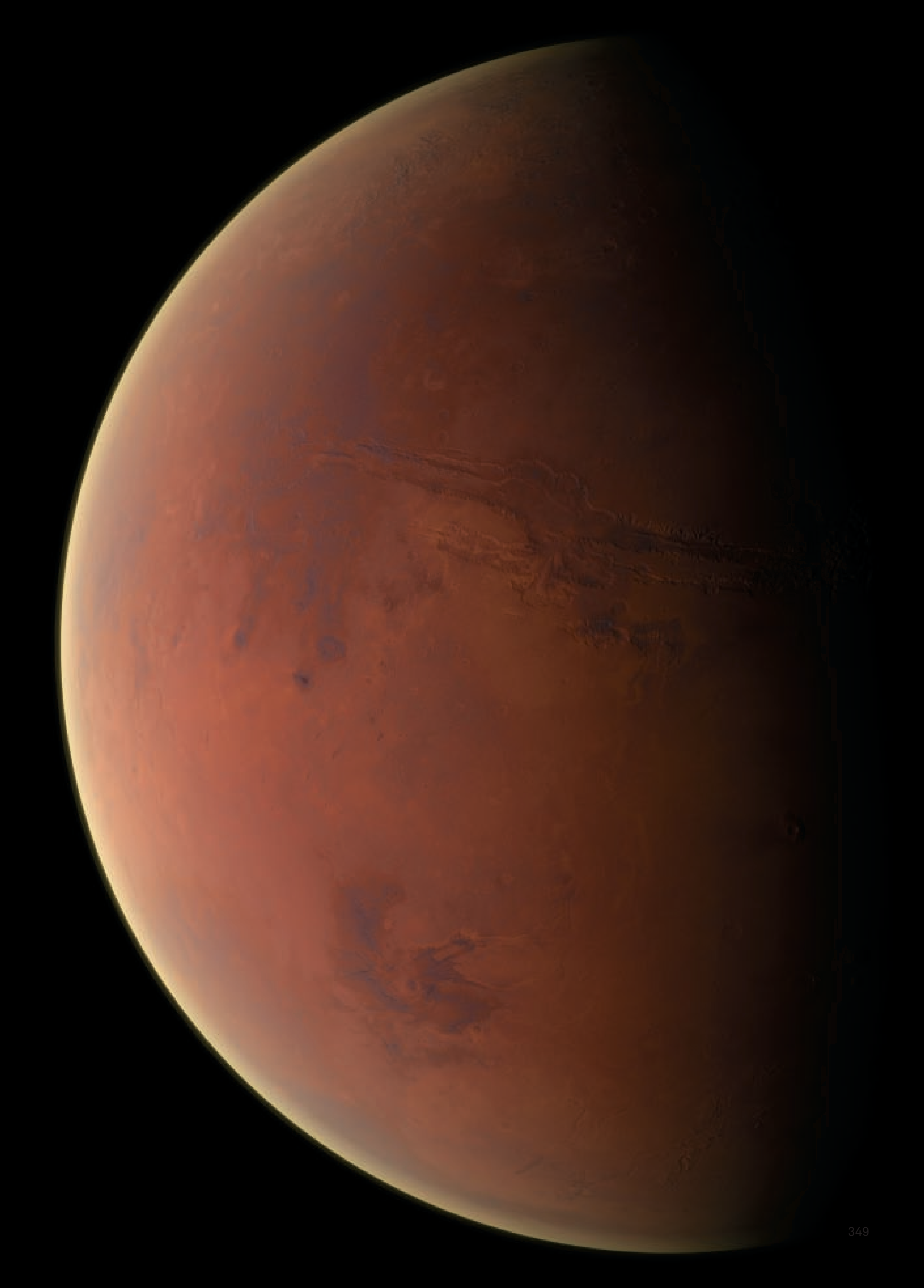
**9. As you see it, what is the place of the narrative sciences, such as literature or philosophy, on the horizon of new virtual utopias?**

**V.** Philosophy is no longer practised because it calls ineluctably for writing and reading — its medium is the book. As to narrative: everything is narrative, everything is a story. The Americans call it storytelling, and Salmon, a French author, explains it in his recent book by the same title. Politics, the economic crisis, news and the weather; they are all storytelling. Instead of reflection, narration. Instead of logical thinking, fables. Instead of mores, the moral of a story.

**G.** The latest stories I have read with interest are in Somadeva's *Ocean of the Rivers of Stories*, a classical work in Sanskrit from the 11th century with a beautiful flow of stories that we can enjoy when we realize that not everyone is obsessed with the same things. History is the tracing of many forms of liberty. How many pages of African or Asian history are there in a textbook from our country? Do they not have any history?

**FM.** Unlike those who think in terms of unstoppable specialization, I believe that all disciplines will converge into a more or less broad and shared structure. Philosophy, literature, economics, the arts and even gastronomy tend to apply scientific models to explain themselves and to explain the fraction of the world that falls into their area of expertise. The inner structures employed by science and linked to network theories seem to be the horizon they will all approach if they want to survive as autonomous yet simultaneously interconnected sectors. In that sense, no matter how paradoxical it may seem, I believe that we are moving towards a situation similar to the pre-Enlightenment, where knowledge was almost united. At that time, the unifying metaphor was religious, but the metaphors are now supplied by science, a religion like any other.

**Z.** The technological changes that modify how people relate to each other are usually accompanied by changes in the narrative sciences. I have mixed feelings about this. On one hand, I perceive a crisis in philosophy and thought motivated by the speed imposed by the media (I share Bourdieu's forceful observation that thinking is not possible without time to think). On the other hand, I am aware that before the Internet, a few people wrote and many read, while now, "everyone" writes and a few read. Thus, the formerly unidirectional dynamic has changed, as have strategies of access to readers. Those strategies are increasingly aimed at turning us into "prosumers" of text, capturing the "greatest number of eyes" to read/see the bestsellers of yesterday, today and tomorrow. Of course the horizontalization of the Internet is a pure fallacy because, while everyone writes, not everyone has the same "visibility." On the other hand, the Internet is favoring a more profound change through the publication of personal stories (blogs) and the archiving of people's lives and thoughts. Moreover, I believe that literature, philosophy and I would even say other narrative sciences such as ethnography converge in new formats of virtual utopia. Writing increasingly takes more popular forms, resulting in the proliferation of hybrid texts that are frequently participatory and habitually aphoristic… Lack of time to think means it is better to read more and more quickly (so much to see, such fleeting tendencies).



**BIOGRAPHIES**

**Antoni Abad**
A multimedia artist and graduate in the History of Art from the University of Barcelona, Abad works in the field of sculpture, installation and net.art, using in his practice the new resources offered by digital technology. He was awarded a Golden Nica at the 2006 Ars Electronica Festival in the category of digital communities. In 1999, he won the Arco Electrónico award with his piece *1.000.000*. His projects have been exhibited at the Museu d'Art Contemporani (MACBA), Barcelona; Museo Nacional Centro de Arte Reina Sofía (MNCARS), Madrid; P.S.1., Long Island City, New York; Hamburger Bahnhof, Berlin; Museo de Arte Moderno de Buenos Aires; ZKM'net_condition, Karlsruhe; and Dapertutto/ Venice Biennale, among other venues.
<http://www.zexe.net>

**Aetherbits**
Aetherbits is an international new media artists' collective comprising Mariela Cádiz (Spain), Kent Clelland (USA) and Denis Lelong (France). They met in 1994 in the USA at California Institute of the Arts (CalArts), since then they have collaborated regularly. Their works range from award winning computer animation films to interactive installations, live cinema performances and compositions for new media.
Mariela Cádiz studied Fine Arts in Madrid and Denis Lelong studied metal sculpture in Paris. They both specialized in new technologies for visual media at CalArts. They currently live in France and work in new media. Computer musician Kent Clelland has Masters in Composition for Interactive Media at CalArts. He's currently living in Germany, designing software for audio and video.
<http://aetherbits.net>

**Antonio Acín**
A telecommunications engineer from the Polytechnic University of Catalonia with a degree in Physics from the University of Barcelona (1997), he obtained his doctorate in Physics from that university (2001). He is currently a researcher at the Catalan Institute of Research and Advanced Studies (ICREA) in the Institute of Photon Studies (ICFO), where he directs the Quantum Information Theory Group. In 2008 he was awarded one of the European Research Council's scholarships for young researchers.
<http://icrea.cat>, <http://icfo.es>

**Pau Alsina**
Professor of Humanities at the Open University of Catalonia (UOC). He is a specialist in digital culture, aesthetics and the history of media arts. He also directs *Artnodes,* the UOC's art, science and technology magazine. He is a researcher at the Internet Interdisciplinary Institute (IN3) and cofounder and coordinator of the YASMIN network of art, science and technology in the Mediterranean countries along with Leonardo/ ISAT/OLATS (University of Athens and Unesco Digitarts). He is also coordinator of the Leonardolabs project in Spanish (ISAST). He was a co-writer of the *White Paper on Art, Science and Technology in the Spanish State* for the Spanish Foundation for Science and Technology (Strategic Culture Plan of Barcelona) and has carried out various studies of centers for the production of art and new media. He has published articles and essays. He recently published the book *Arte, ciencia y technología* (Editorial UOC, 2007).
<http://www.artnodes.org>

**Eugenio Ampudia**
One of the best-known Spanish video artists. This year he received the Delfina Foundation scholarship (London) and the AECA prize for the best living Spanish artist shown at ARCO 2008. His work explores the very idea of "artistic process" from the standpoint of both the meaning of an artwork itself and the traditional mechanisms for promoting, contemplating and interpreting it.
His recent exhibitions include *H2O*, at the Kursaal San Sebastián; *Shaping a Space*, Mario Sequeira Gallery, Braga; *Momentos-New Perspectives on Spanish Contemporary Photography*, Stockholm; *BIACS*, Bienal Internacional de Arte Contemporáneo de Sevilla, Seville and Granada; *Alternative Revolutions, TINA B*, at the 2008 Prague Contemporary Art Fair, Prague.
<http://www.eugenioampudia.net>

**Marcel·lí Antúnez**
Internationally known for his mecatronic performances and robotic installations. His work has been characterized by a concern for the human condition, at first from the perspective of tribal performance with the collective, La Fura dels Baus (of which he was founder, artistic coordinator, musician and performed from 1979 to 1989), and later alone.
The use and abuse of scientific and technological elements in his work since the 1990s as well as their interpretation with unique and personal devices gave this work a renewed cosmogony that is warm, raw and ironic, with room for such classic subjects as feelings, identity eschatology and death, elements that take on an ironic and human dimension in his work and provoke spontaneous reactions by spectators.
<http://www.marceliantunez.com>

**Juan Aranzadi**
He studied Philosophy in Salamanca, Madrid and San Sebastian. He earned his doctorate in Anthropology at the UNED. He worked in the research section of *Pueblo* newspaper (1972-1977) and in the 1980s he wrote assiduously for the magazines, *El Viejo Topo, Triunfo* and *Tiempo de Historia.* He was professor of History of Religions and Philosophy of Symbolic Forms at the Philosophy Department of the University of the Basque Country (1983-1989). Since 1990, he has been professor of Social Anthropology at the UNED. His most important publications are *El escudo de Arquíloco: sobre mesías, mártires y terroristas* (vol. 1: "Sangre vasca"; vol. 2: "El nuevo Israel americano y la restauración de Sion"; Antonio Machado Libros, 2002). He contributes regularly to the newspaper *El País*.

**Pablo Armesto**
Visual Artist. He has a Diploma in Illustration and Design from the School of Fine Arts of Gijon. Although his training was image-oriented, his work has been evolving towards installations and public art, a domain where he looks for interactivity between the medium and the beholder. In his pieces, he explores critical issues of networks, displacements and the very concept of space as subject matter. He has won several dis-

tinctions, including the Jovellanos (2006) and Alnorte (2005) grants. His work was included in a touring show on Visual Arts from the Principality of Asturias, presented in Salamanca, Madrid and Brussels, (2006); and Loirent (2005).
<http://www.inab.org>
<http://www.gen-es.org>

**Yayo Aznar Almazán**
A tenured professor at the UNED, he specializes in Contemporary Art since 1968, with particular interest in subjects relating to art, politics and power. In that sense, he has published considerable material, given numerous lectures and participated in different projects.
With Dr. Javier Hernando Carrasco, he directed the *Arte Hoy* collection for Nerea Publishers. He collaborates on the Masters in Theory and Practice of Contemporary Art at the Faculty of Fine Arts of the Complutense University of Madrid.

**José María Baldasano**
Doctor of Chemical Sciences (1983) from the University of Barcelona and a Chemical Engineer (1976) trained at the National Polytechnic Institute of Toulouse, he earned his MS in Chemical Engineering (1979) at Sherbrooke University in Quebec.
As senior professor of Environmental Engineering at the Polytechnic University of Catalonia. He has written over 235 articles and is the co-editor and author of 14 books. He was a consultant on the United Nations' Programme for the Environment (PNUMA) and is an expert on the United Nations' Intergovernmental Panel for climate change (IPCC). He was awarded the Rey Jaime I Prize for Environmental Protection (1997) and is currently director of the Earth Sciences Area at the Barcelona Supercomputing Center.
<http://www.bsc.es>

**José Manuel Berenguer**
Conductor of Orquesta del Caos and Director of Festival Música13, founder of NauCôclea, a member of the Académie Internationale de Musique Eléctroacoustique of Bourges and Honorary President of the International Confederation of Electro-acoustic Music of the UNESCO International Music Council. His practice focuses on installations, real time and interactivity, addressing issues like philosophy and history of science, the limits of language, ethics, artificial life and intelligence, robotics, information metabolism, as well as the very limits of human understanding and perception.
<http://www.sonoscop.net/jumb>

**Álvaro Bermejo**
A writer and journalist, he is a History and Anthropology graduate from the Autonomous University of Barcelona. He currently contributes to various communications media and coordinates the publishing of transversal works that connect art, literature, science and society. After coordinating the international lecture series, *Más de Seis Propuestas para el Próximo Milenio,* he has continued to collaborate with the world of contemporary art. He participated in earlier editions of *banquete_* organized by Medialabmadrid and the Conde Duque Cultural Centre, Madrid. His last publishes are, among others, *El Evangelio del Tibet* (Algaida, 2008) and *Contracorriente* (Nerea, 2009).

**Clara Boj, Diego Díaz**
A two-artist collective created in 2000. Clara Boj has a doctorate in Fine Arts while Diego Díaz has a degree in Fine Arts both from the Polytechnic University of Valencia. They combine their art practice with wide-ranging research into the field of interactive environments, urban strategies, and network experiences, connecting physical and digital spaces and generating ongoing links between traditional and innovative forms of social interaction.
They have been artists-in-residence at the Mixed Reality Lab, National University of Singapore, and their work has been exhibited at the Singapore Art Museum; Llotja del Peix, Alicante, Spain; MediaLabMadrid; and Kiasma Museum, Helsinki, among others.
<http://www.lalalab.org>

**José Luis Brea**
A tenured professor of Aesthetics and Theory of Contemporary Art at Carlos III University in Madrid, he directs the magazines, *Estudios Visuales* and *Salonkritik* and regional editor of *Rhizome*. His most recent books include: *Cultura RAM: mutaciones de la cultura en la era de su distribución electrónica* (Gedisa, 2007); *Noli me legere: el enfoque retórico y el primado de la alegoría en el arte contemporáneo* (CENDEAC, 2007). His most recent exhibitions include: *Economías identitarias en la era del capitalismo informacional*, Sala Verónicas, Murcia, (2004). He is a member of the advisory council of the Artnodes project (UOC) and member of the Humanities Commission of the Spanish Foundation for Science and Technology (FECYT). He directed the I International Congress of Visual Studies (at ARCO in 2004) and the International Meeting of Visual Studies (at ARCO in 2006).
<http://joseluisbrea.net>

**Carlos Briones**
Scientist and writer, he is a Doctor of Chemical Sciences specialized in Biochemistry and Molecular Biology, on the research faculty of the Astrobiology Center (CSIC-INTA, associated with the NASA Astrobiology Institute). His scientific interests focus on the origin and early evolution of life, bionanotechnology and the development of biosensors. He is the author of more than 50 research articles in international reviews as well as 6 patents and numerous lectures in congresses. He has also cultivated literature and music and is author of the poetry books *De donde estás ausente* (Hiperión, 1993; VIII Premio de Poesía Hiperión) and *Memoria de la luz* (DVD Ediciones, 2002).
<http://www.cab.inta.es>

**Daniel Canogar**
Has a master in Photography from New York University and the International Center for Photography. He has published, *Ingrávidos* (Fundación Telefónica, 2003) and various essays on architecture of the image, contemporary photography and new-media art. He is currently the artistic director of VIDA. His work has been exhibited at Palacio de Velázquez, Madrid; Gale ría Max Estrella, Madrid; Galería Filomena Soares, Lisbon; Galerie Guy Bärtschi, Geneva; Caprice Horn, Berlin; Mimmo Scognamiglio Artecontemporanea, Milan; Centre d'Art Santa Mònica, Barcelona; Museo Alejandro Otero, Caracas; Wexner Center for the Arts, Ohio; Kunstsammlung Nordrhein Westfalen, Dusseldorf; Hamburger Banhof Museum, Berlín, and the Mattress Factory Museum, Pittsburgh.
<http://www.danielcanogar.com>

**Óscar Carpintero**
A professor of Applied Economics at Valladolid University, he has written over thirty works in recent years on ecological economics, the environmental sustainability of the Spanish economy and housing and finances, among other subjects. Outstanding among his publications are the following books: *La bioeconomía de Georgescu-Roegen* (Montesinos, 2006), *El metabolismo de la economía española: recursos naturales y huella ecológica, 1955-2000* (Fundación César Manrique, 2005). He edited and translated *Ensayos bioeconómicos*, by Nicholas Georgescu-Roegen (Los Libros de la Catarata, 2007), and wrote *El balance nacional de la economía española, 1984-2000* (FUNCAS, 2002, in collaboration with J. M. Naredo), among others. Also, with J. M. Naredo and Carmen Marcos, he published the book *Patrimonio inmobiliario y balance nacional de la economía española, 1991-2004* (FUNCAS, 2005).

**Álvaro Castro**
A researcher and architect trained in computing languages and the study of space, Castro's work focuses on the wider field of architecture and the generation of visual solutions for urban environments and non-linear systems. At present, he is collaborating with the R&D division of Nextlimit Technologies. His work has been presented at the Ars Electronica Festival, MediaLabMadrid-Centro Cultural Conde Duque (2006), and CAB, Burgos (2004).
<http://www.alvarocastro.es>

**Juan Ignacio Cirac**
He earned his degree (1988) and his doctorate (1991) at the Complutense University of Madrid , he was tenured professor at the University of Castile-La Mancha (1991-1996), during which time he spent a year and a half in the Joint Institute for Laboratory Astrophysics at the University of Colorado and other periods at the Institute of Theoretical, Atomic and Molecular Physics at Harvard University. In 1996 he obtained the post of Professor at the University of Innsbruck's Institute of Theoretical Physics (1996) and he as been director of the Division of Theory at the Max Planck Institute of Quantum Optics since 2001, as well as honorary professor at the Technical University of Munich. He has received various prizes, including the Principe de Asturias Research Prize, the International Quantum Communication Award and the Quantum Electronic Prize of the ESF. He is Doctor *Honoris Causa* from the universities of Castile-La Mancha and the Polytechnic University of Catalonia.

**Alfredo Colunga**
This multimedia artist studied technical engineering at the University of Oviedo, and has also studied History, Philosophy and Audiovisual Language. Literary experimentation, the research of new audiovisual media and processes and the development of a systemic perspective on reality are some of the conceptual driving forces in his current practice. In recent years, he has taken part in the Big Social Game International Art Biennale (Turin, 2002), in the *Transhumanism and Bioethics* Conference (Yale University, 2004); and has exhibited his work at Galería Vértice (Oviedo, 2005), among other venues. In 2007 he presented *La palabra que falta* at the Gijon Film Festival. He has authored and directed over 60 scientific and didactic audiovisual pieces and patented a number of audiovisual processes.
<http://www.alfredocolunga.com>
<http://www.edayforenergy.org>

**Capi Corrales**
As a professor of the Department of Algebra at the Mathematics Department of the Complutense University of Madrid, she combines research into number theory and the relation between contemporary arts and sciences with the popularization of mathematics. She received the Complutense Teacher's Prize (2000) and the very first Laura Iglesias National Prize for Scientific Popularization (2007). She won the Art and Law Foundation's contest of texts on art (2008). She is the author of the following books: *Contando el espacio* (Despacio, 2000) and *Un triángulo especial: Prado, Reina Sofía y Thyssen-Bornemisza* (Proyecto Sur, 2005); and with Carlos Andradas she directed *400 años de matemáticas en torno al teorema de Fermat* (Ediciones Complutense, 1999). With Paloma Alcalá Cortijo and Julia López Giráldez she directed *Ni tontas ni locas* (FECYT, 2008).

**Javier DeFelipe**
A professor of research at the Santiago Ramón y Cajal Neurobiology Institute, he is considered one of the world's most highly qualified specialists on the microanatomy of the brain. He co-directed the Neurolab mission for NASA, sending rats into space to study how the lack of gravity affected their brains. He was the first Spanish scientist to receive the prestigious Krieg Cortical Kudos Prize from the Cajal Club in the United States.
<http://www.cajal.csic.es>

**Ángela Delgado**
Doctor of Biology, she has been professor at the Autonomous University of Madrid's Department of Biology since 1998. Her main research involves the study of macroevolutionary events that combine neontological and palaeobiological data. Nature is a complex universe with phenomena we want to grasp, understand and solve. She has been developing methodological approaches to studies of theoretical morphology, morphological integration and modularity, producing empirical works on evolutionary processes in the organization of phenotypes in birds, crocodiles and dinosaurs, while also exploring the shared borders between art and science.
<http://www.uam.es>

**Javier Echeverría**
Research professor at the CSIC's Institute of Philosophy (on leave) and researcher at the Basque Science Foundation (Ikerbasque) of the University of the Basque Country's Department of Sociology 2, he is currently carrying out research at the University of Nevada's Center for Basque Studies (Reno, United States). He has been awarded the Anagrama Prize for Essays (1995), the Euskadi Research Prize (1997), and the National Essay Prize (2000). Among his books are: *Los Señores del Aire: Telépolis y el tercer entorno* (Destino, 1999), *Un mundo virtual* (Debolsillo, 2000), *Ciencia y valores* (Destino, 2002) and *La revolución tecnocientífica* (Fondo de Cultura Económica, 2003).

**Santiago Eraso**
After receiving his degree in Philosophy and Letters, he was director of Culture, Education and Youth for the Tolosa City Government (1982-1987) and director of Arteleku, Center for Contemporary Art and Culture (1987-2007).
He is now part of the UNIA Arteypensamiento contents team at the International University of Andalusia and collaborates independently with different public institutions, cultural companies and social movements.
He collaborates with various publications, contributing to the debate on the function of art and culture in contemporary society. He writes regularly for the newspaper, *Diario Vasco de Gipuzkoa* and the "Culturas" supplement to *La Vanguardia* in Barcelona.

**Escoitar**
A collective of sound artists and activists, Escoitar is made up by Carlos Suárez Sánchez, Julio Gómez, Juan Gil Rodríguez, Horacio González, Chiu Longuita and Bernio Molina. Anthropologists, musicologists, fine art graduates or multimedia artists, their main objective is the fostering and promotion of sound as a new way of knowing society. Their activities focus on the conservation of sonic memory, the valuing of our immaterial cultural heritage, fostering the participation of listeners in the configuration of the sonic heritage and field work, recordings and contextualization of the country's environmental sounds from artistic, ethnomusicological, bioacoustic and anthropological viewpoints.
<http://www.escoitar.org>

**Evru**
One of the first digital artists in Spain. In 1968, the artist Albert Porta transformed himself into Zush and later, with the arrival of the new millennium, into Evru. In 1975, a scholarship from the Juan March Foundation allowed him to study holography at MIT, Boston. In the 1980s he began to apply digital technology to his work. His practice is based on a concept he has coined himself as PsicoManualDigital. He has exhibited his works in major retrospective shows, including The Art of Today Museum, Beijing (2007), MACBA (2001), or MNCARS (2000). In 1999, he won the Laus Prize for his piece *Psicomanualdigital*. He has work in the collections of MoMA and the Guggenheim Museum, New York.
<http://www.evru.org>
<http://www.tecura.org>

**Agustín Fernández Mallo**
After completing his degree in Physical Sciences, he coined the term "post-poetic poetry", publishing that movement founding manifestos in *Lateral* magazine (December 2004) and *Quimera* (2006). He is the author of the novels, *Nocilla dream, Nocilla Experience* and *Nocilla Lab*, which make up the *Proyecto Nocilla* trilogy. His books of poems are: *Carne de píxel*, *Joan Fontaine Odisea (mi decons trucción)*, *Creta Lateral Travelling* and *Yo siempre regreso a los pezones y al punto 7 del "Tractatus."* He has been included in various poetry collections, most recently: *Antología del poema en prosa en caste llano: campo abierto*. He writes for various specialized media and press.

**Ramon Folch**
A doctor of Biology and Socio-Ecologist, he is a territorial and urban researcher and manager. Director of the ERF Management and Environmental Communication studio and president of the Social Council at the Polytechnic University of Catalonia, he is also Secretary General of the International Advisory Council of the Latin-American Forum for Environmental Sciences and senior professor UNESCO/FLACAM for Sustainable Development, member of Plant Ecology at the Institute of Catalan Studies. He was director of environmental services for the Regional Government of Barcelona and the Generalitat of Catalonia and environmental management consultant for Unesco, as well as member of the UNESCO and EU/ commitees. He has written and directed numerous articles and books, and he was director script writer for TV and directed and curated exhibitions.
<http://www.erf.cat>
<http://www.sostenible.cat>

**Joan Fontcuberta**
A photographer, theorist, critic, teacher, exhibition curator and guest lecturer at international universities and at the UPF (Barcelona) since 1993. Their works advocated the need for profound self-reflection through images. He has authored several books, including *El beso de Judas, Fotografía. Crisis de historia* and *Estética Fotográfica*. His work has been exhibit ed at Galerie VU, Quebec, (2007); *Aperture Foundation*, New York (2006); the Cervantes Institute Paris (2005); Galerie Synopsis, Lausanne (2004); ARTIUM, Vitoria (2003); Zabriskie Gallery, New York (2003 and 2004); Palazzo delle Esposizioni, Rome (2001).

**Dora García**
A Fine Arts graduate from the University of Salamanca and the Rijksakademie, Amsterdam, she focuses her work mainly on the creation of contexts and situations in which the traditional emitter-message-receiver communicational pattern is altered.
She has participated in exhibitions including The Sydney Biennale 2008; Münster Sculpture Projects, 2007; Istambul Biennale 2003 and Manifesta, 1998.
She has exhibited her work, among other venues, in SMAK, Ghent; GFZK, Leipzig; at the Museum of Contemporary Art of Barcelona (MACBA) and the Reina Sofía Museum of Contemporary Art (MNCARS) in Madrid, among others.
<http://www.doragarcia.net>, <http://www.doragarcia.net/todaslashistorias>

**Daniel García Andújar**
A multimedia artist, García Andújar began his art practice in the late 1980s, in the field of video art. A member of Irrational.org, (1996) he founded the *Technologies To The People (TTTP)* project. He explores concepts such as virtuality, authenticity, copyright, marketing strategies, relationship between media and power, as well as global access to the technological communication networks. His projects have been presented, among other venues, at Hartware MedienKunstVerein, PHOENIX Halle Dortmund; CCA Glasgow; PhotoEspaña2006, Matadero, Madrid; Palau de la Virreina, Barcelona (2006); Manifiesta 4, Frankfurt (2002); ZKM, Karlsruhe; George Pompidou, Paris; Transmediale 01, Berlin (2001); Microwave Festival, Hong Kong; Portland Art Museum, USA (2000); ICA, London (1999); and Apex Art CP, New York (1998).
<http://www.danielandujar.org>

**Ernesto García Camarero**
A mathematician, computer scientist, librarian and science historian, he is Professor of Theory of Automatons and Formal Languages at the Complutense University of Madrid and at various Latin American universities. He has worked on applying the linguistic model to the simulation of behaviour and the representation of knowledge through semantic networks. Director of Centro de Cálculo at UCM and President of the Spanish Society of Science and Technical and of II International Congress on Humanities and Social Science Databases, he is the author of numerous works, including *Computer art: l'ordinateur peut-il créer une oeuvre d'art?* (IBM Informatique) and *L'art cybernétique* (SIGMA 9, 1973). He developed the automation system at the Biblioteca Nacional, Madrid (1982-1983) and the multimedia enciclopedia Project, *Quinientos años después*.

**Marta de Gonzalo, Publio Pérez Prieto**
These two artists work collectively since 1996, when they met at the Rietveld Academie in Amsterdam. They understand cultural production as a poetic instrument of active thought leading to other personal and collective attitudes. As secondary school teachers, they work on artistic thought and practice as a means of audiovisual literacy and critical pedagogy. They also train other professors and artists, as well as carrying out self-representation projects with youth. They have exhibited in the Tinbox Gallery, Bordeaux; the Patio Herreriano Museum, Valladolid; the Edinburgh Sculpture Workshop; Matadero, Madrid (2008); the Foundació "La Caixa", Lérida (2006), the Foundació Espais, Gerona (2005), Medialabmadrid (2004) and MEIAC, Badajoz (2002).
<http://www.martaypublio.net>

**Vicente Guallart**
One of the Spanish architects best known on the international scene, he created Guallart Architects in 2000. His projects are developed where architecture, nature and new technologies meet. As director of the Institute of Advance Architecture of Catalonia, he dedicates part of his time to research and education. He is co-author of various books and is currently preparing his next book, *Geologics.* He has given lectures in universities and institutions all over the world. His work has been exhibited at the biennales of Venice, Valencia and Sao Paulo, the Museum of Modern Art (MOMA) in New York, the Museum of Contemporary Art in Barcelona (MACBA) and the Valencian Institute of Modern Art (IVAM).

**Ramón Guardans**
After completing his degree in biological sciences, he worked at the Physical Chemistry Laboratory of the Free University of Brussels (1978-1983). He was part of the Institute of Radiological Protection and the Research Group for Eco-toxicology of Atmospheric Contamination at the Spanish Ministry of Science and Technology's Center for Energy, Environmental and Technological Research (CIEMAT) (1987-2000). Since 1993 he has been the United Nations' vice-president of Effects Group, LRTAP and member of GESAMP. He collaborates as scientific advisor to *La Fura dels Baus* and to artists Sergio Caballero and Marcel·lí Antúnez. He directs and produces the visual and sound project, *Algorithmic Echolocation* between ZKM in Karlsruhe, Medialabmadrid and Soundplots.

**Hackitectura.net**
A collective comprising architects, artists, computer specialists and activists, devoted to the research and visualisation of territories emerging in the interstices between physical spaces and the social and communicational dynamics of the Net. Founded by Pablo de Soto, Sergio Moreno and José Pérez de Lama (also know as *Osfa* on the web), Hackitectura collaborates on a regular basis with other related groups and projects. Their productions include *Fadaiat*, Tarifa/Tangiers (2004-2005), *Emergent Geolab*, Extremadura (2007), *Situation Room*, Gijon (2008), and *Water 4 Bits*, Seville (2008). In 2006 they won an international contest for the construction of the Plaza de Las Libertades in Seville.
<http://mcs.hackitectura.net>
<http://fadaiat.net>>

**Ricardo Iglesias**
After graduating in Humanities at the Autonomous University of Madrid. Cofounder of the interdisciplinary collaborative Proyecto ß, he currently imparts courses on interactive systems and interfaces in various universities and educational centres. In his installations and robots, Iglesias explores the complex world of relationships taking place between the subject, controlling powers and the boundaries separating the natural from the artificial. He has taken part in many Spanish and international art events, including *Rencontres Internationales*, Paris/Berlin/Madrid (2008), *Palabras Corrientes*, New York (2008); Beijing (2007), Resplandores, Buenos Aires (2007), FILE, Rio de Janeiro, 2006, Observatori, Valencia (2006); Cyberia 02: Arte, Interactividad y Máquinas, Santander (2002); Log-os, Hannover (2000); Webby Prize Competition, San Francisco (2000); ARCO, Madrid (2004, 2002, 2001, 2000); Net Condition, Karlsruhe/Graz/Tokyo/Barcelona (1999).
<http://www.mediainterventions.net>

**Influenza**
A creation and research collective comprising Raquel Rennó and Rafael Marchetti. Fine Arts graduate Rafael Marchetti (Argentina) has been working since 200 in programming in the creation of digital media. In turn, Raquel Rennó (Brazil) is a university lecturer and doctor of Communication and Semiotic Studies. Both have been artists-in-residence at MedialabMadrid, and their projects have won distinctions in FILE (2004) and Prog:me (2005). Their work has been exhibited, among others, at ACM Multimedia, Singapore, FILE, Sao Paulo and Rio de Janeiro, Tohu Bohu Gallery, Marseilles, Comafosca, Nuevas Geografías, Mexico, Accea, Armenia, Soundtoys, Runme, Break 2.3, Ljubljana, Viper, Basel, VII Digital Art Salon in Havana, and Ars Electronica, Linz.
<http://www.influenza.etc.br>

**Concha Jerez, José Iges**
Both live and work in Madrid. Intermedia artists and pioneers of electronic art in Spain. They have been collaborating together since 1989, when they first began to render their ideas in works of radio art, performances, installations and intermedia concerts. They have taken part in many international exhibitions and internatutical festivals.

Concha Jerez is a political scientist. From her early work developing installations in large spaces, she evolved towards performance, intermedia concerts and radio artworks. José Iges is an industrial engineer with a doctorate in Computer Science. He works on radio art and in performances, installations and intermedia concerts. He has been director the Ars Sonora, program in RNE (1985-2008). He is coordinator of Ars Acustica (UER).
<http://www.joseiges.com>
<http://www.conchajerez.com>

**Kònic Thtr**
Rosa Sánchez and Alain Baumann comprise this multimedia art platform. Rosa Sánchez is, a performer, choreographer and the art director of Kònic Thtr. Alain Baumann is a musician and a researcher in new sound generating systems. He is also in charge of developing the interactive systems used in Kònic Thtr projects. Both work at the intersection of art, science and new technologies, focusing their operations on the research and use of interactive technology applied to performative projects involving dance, performance and multimedia, as well as to the field of video-art, interactive installations and Augmented Reality. They have presented their work, among other event, at the III Bienal Internacional de Arte Contemporáneo Sevilla (2008) BODIG Festival, Istanbul (2008); CECN - Centre des écritures contemporaines et numériques, Mons, Belgium (2008); File Festival, Sao Paulo (2006); or Mercat de les Flors, Festival d'Òpera de Butxaca i Noves Creacions and Festival neo, Noves Escenes Obertes, Barcelona (2006).
<http://www.koniclab.info>

**Laboratorio de Luz**
Since 1990, Laboratorio de Luz, located at the School of Fine Arts of Valencia, works as a space for encounter, study and research into aesthetic and expressive principles related to image-light. At present, members of the laboratory come from a variety of backgrounds working between the collective and the individual *Light Modulator 3.0* project, Laboratorio de Luz comprised Amparo Carbonell, Salomé Cuesta, Maribel Doménech, Dolores Furió, Carlos García Miragall, Trinidad Gracia, Moisés Mañas, Emilio Martínez, María José Martínez de Pisón, Emanuele Mazza, Dolores Piqueras, Francisco Sanmartín, Ulrike Gollner and Jeldrik Schmuch. The lab publishes the magazine *Arte: Proyectos e Ideas*.
<http://www.upv.es/laboluz/revista/>
<http://www.laboluz.org>

**Joan Leandre**
A member of the OVNI Archives since 1994, he worked on series of media interruption (or continuity) from 1994 to 1996, including MAP (Mega Assemble Project), Fundación Zero and Serial Monuments. In 1995-1997 he carried out the Oigo Rom project. In 1998 he became involved in Archivos Presidente. In 1999 he went back to work in the field of mass entertainment software and began the serial projects *Retroyou* (RC) and *Retroyou* (*NostalG*), the long work-in-progress, *retroyou Nostalg2* and the indefinitely delayed *Boot Profundo*. Other collective projects from that period were Velvet Strike with Brody Condon and Anne-Marie Schleiner and *Archivos Babilonia*. He is currently in a floating state among diverse considerations of the iron bird's call and its flight into the automatic sunset… in the name of Kernel.
<http://www.retroyou.org>

**Maciej Lewenstein**
He has been a researcher at the Universities of Warsaw, Essen, Harvard, Oregon, Colorado, the CEA in Paris and Hannover. Doctor Lewenstein is a world expert in various fields of photon science, including the most advanced quantum optics, quantum computing and "attoscience", where he has made pioneering contributions leading to major advances in that field. In particular, he is one of the inventors of the technology that permits the shortest flashes of light yet to be achieved.

**Jacob Lillemose**
A doctor of Philosophy, he is a researcher at Copenhagen University's Institute of Art and Cultural Studies. He is currently researching the history and theory of computer-generated art. He co-directs Art Node. He also curates art shows and writes art criticism. He recently wrote two texts about the work of Daniel García Andújar: *Free Software on the Surface, behind the Screen and in a Cultural Kaleidoscope* (Artnode, 2007) and *Does Free Software have an Image Problem?* (Nai, at press).
<http://www.artnode.org>

**Susanna Manrubia**
This researcher won her degree in Physics at the University of Barcelona and her Doctorate in Sciences at the Polytechnic University of Catalonia. She carries out her science work at the Astrobiology Center (INTA-CSIC), where she handles trans-disciplinary problems concerning the evolution and adaptation of organisms. She carried out post-doctoral studies at the Max Planck Institute in Berlin, researching social systems and analyzing the apparition of non-supervised order. In 2005 she received *Diaro Médico*'s Prize for the best scientific ideas of the year. Besides her research, she works to popularize scientific knowledge.
<http://www.upc.es>

**Pedro C. Marijuán**
A computer scientist, he received his engineering degree at the Polytechnic University of Catalonia and his doctorate in Cognitive Neuroscience at the University of Barcelona. His research focuses on the dynamics of information beginning with molecular systems of the cell and reaching as far as the functioning of the nervous system and the integration of individuals into complex societies. In the 1990s, he worked with Michael Conrad to promote the FIS (Foundations of Information Science) initiative. Until recently, he taught and did research at the SAMCA professorship of Engineering and Technological Development of the Superior Polytechnical Center of the University of Zaragoza. He now directs the Bioinformation and Systems Biology Group at the Aragonese Institute of Health Sciences.
<http://www.cps.unizar.es>

**José Ángel Martín-Gago**
A doctor of Physical Sciences and scientific researcher at the Superior Council of Scientific Research (CSIC) in the Institute of the Science of Materials in Madrid, he now directs a

research laboratory for studying the structure of nano-systems. Author of almost 100 publications in prestigious international scientific reviews, as well as numerous works and lectures to popularize scientific knowledge, he works mainly on the interaction of organic molecules and bio-molecules with the surfaces of materials. He uses a tunnel-effect microscope and synchrotron radiation. Collaborating actively with the Astrobiology Center, he investigates processes of molecular self-organization as a primordial element of chemistry before life.
<http://www.icmm.csic.es/esisna>
<http://www.cab.inta.es>

**Juan Martín Prada**
Author of numerous articles on the theory of contemporary art and new media, he has also written the following books: *La apropiación posmoderna: arte, práctica apropiacionista y teoría de la posmodernidad* (Fundamentos, 2001) and *Las nuevas condiciones del arte contemporáneo* (Briseño, 2003). He has griten for magazines, including *REIS*, *Red Digital*, *Papiers d'Art*, *A Minima*, *Temps d'Art*, *Transversal*, *Exit Books*, *Exit Press*, *Mecad E-journal* and in the "Culturas" supplement of the *La Vanguardia* (Barcelona), among many other printed and digital publications. He was a member of the Humanities Commission and the Art-Science-Technology Group at the Spanish Foundation for Science and Technology (FECYT, 2004-2005). He is now a tenured professor at the University of Cadiz's School of Social Sciences and Communication.

**Jorge Luis Marzo**
Art historian, curator of exhibitions, writer and professor. His latest projects are *El (D)efecto Barroco* (CCCB, 2010), *Low-cost* (FAD, 2009), *Spots Electorales: el Espectáculo de la Democracia* (Palau de la Virreina, 2008), *Hempreslaradio.net* (CASM, 2006-2007) and *Tour-ismes* (Fundació Tàpies, 2004). He recently published *Spots electorales: el espectáculo de la democracia* (Turner, 2008), *Arte moderno y franquismo: los orígenes conservadores de la vanguardia y de la política artística en España* (Fundació Espais, 2008), *Fotografía y activismo social* (Gustavo Gili, 2006), *Me, Mycell and I: tecnología, movilidad y vida social* (Fundació Tàpies, 2003) and *Planeta Kurtz* (Random House Mondadori, 2002).

**José Antonio Millán**
For years, José Antonio Millán has been creating digital cultural projects, beginning with the Virtual Cervantes Center (1996-1997) and the first CD-ROM of the dictionary of the Royal Academy of Spain (1995). His website,<http://www.librosybitios.com>, has been a constant point of reference for digital publishing in recent years. He has worked on communications with icons and is the author of the books *¡No!* and *¡Contra!* (Gustavo Gili, 2004). He also has the website *Rutas por la Iconosfera*. He has written novels, books of stories and children's books. His work has been transated into ten languages. Outstanding among his Web-specific projects for image and text are *Piedra* and *Umbrales.*
<http://jamillan.com>

**José María Montoya**
Profesor at ICREA's Laboratory for Complex Systems, Pompeu Fabra University, and the Interuniversity Department of Ecology, University of Alcalá. He is currently researching the stability and functioning of ecosystems using tools derived from graph theory and complex-systems analysis. He also studies food-chain theory and is co-author of the ecosystems equation.

**J. Manuel Moreno**
Doctor of Telecommunications Engineering, he is currently a tenured professor at the Polytechnic University of Catalonia's Department of Electronic Engineering. He coordinated POETIC, the European research project. He has also participated in European research projects related to programmable electronic devices (the RECONF2 and FIPSOC projects) and to models of artificial neuronal networks (the ELENA project). His research interests include techniques of biologically inspired computation, architectures of programmable devices, models of artificial neuronal nets and microelectronic analog-digital design. He has more than 100 publications on these subjects.
<http://www.evolvable.net>
<http://www.res-qualia.net>
<http://www.poeticissue.org>

**Andreea Munteanu**
She took her degree in Physics at the University of Bucharest (1998) and her postgraduate qualification in Astrophysics at the same university, in collaboration with the Università degli Studi of Torino, Italy. Her doctoral dissertation (2000-2003) at the Polytechnic University of Catalonia focused on the applications of non-linear dynamics to astrophysics. She is a postdoctoral researcher in the Systems group (Biomedical Research Park of Barcelona). Her first studies covered the analysis and conception of biological models associated with the generation of an artificial cell. Until February 2007, this work was done in the framework of PACE. She now works on another project, SYNLET. There, she develops models related to cellular networks in cancer.

**José Manuel Naredo**
A doctor of Economics, he belongs to the Spanish government statistics corps. His vast experience as a researcher combines in-depth reflections about the foundations of economic thinking with concrete analyses of subjects that run from the tracking of the current economic situation — relating principally to property aspects — to the functioning of agrarian, urban and industrial systems and their reaction to natural resources and land use. He has been awarded the National Environmental Prize (2000) and the International Geocrítical Prize (2008). His last book is *Raíces económicas del deterioro ecológico y social: más allá de los dogmas* (Siglo XXI, 2007).
<http://www.ub.es/geocrit/-xcol/naredo.htm>

**Neokinok TV**
An experimental television project started in 1998 and coordinated by Daniel Miracle. An Arts Graduate from the University of Cuenca, Miracle lives and develops his work exploring the fields of video, television, the performing arts and sound art. Neokinok has created temporary television channels using both UHF broadcasting technologies and free software through the Net, promoting

active social participation. His work has been shown at a variety of venues and events, including Citemor.tv, Montemor O Velho, (2005); MediaLabMadrid (2003); Espai D'art Contemporani, Castellón, Spain (2002); XXVI Bienal de Arte, Pontevedra (2000); and the Museo de Electrografía, Cuenca (1999).
<http://www.neokinok.tv>
<http://www.tvlata>

**Marina Núñez**
Her works map the geography of post-human beings, a cyborg hybridization of the subject. That intersection of the body and digital technology is a recurrent feature in her videos, paintings, infographs and installations. Nuñez has exhibited her work at the Cervantes Institute, Paris (2006); White Box, New York (2005); Science Museum, London (2004) Hamburger Bahnhof, Berlin (2002); Cairo Biennial (2001); Fundación Pilar y Joan Miró, Palma de Mallorca (2000); and Museo Nacional Centro de Arte Reina Sofía, Madrid (1997), among others.
<http://www.marinanunez.net>

**Karin Ohlenschläger**
A critic and curator of exhibitions specializing in contemporary art and new technologies since 1985, she co-founded and co-directed MedialabMadrid (2002-2006) and has directed, among others, the I International Festival of Art, Science and Technology: Cibervisión, at the Conde Duque Cultural Center (Madrid, 2002); Cibervisión 99, at the Rey Juan Carlos University (Madrid, 1999) and the International Festival of Infoarchitecture, at the Ministry of Development (Madrid, 1997); In Art: International Festival of Cybernetic Art (Tenerife 1996). Her exhibition projects include Eco-media: Ecological Strategies in Today's Art (2007-2008), Digital Transit (2006), banquete_communication *in evolution* (2005) and *banquete_metabolism and communication* (2003). She has given numerous lectures and seminars on media art and contemporary culture.
<http://www.banquete.org>
<http://www.medialabmadrid.org>

**Pedro Ortuño**
Doctor of Fine Arts from the Polytechnic University of Valencia and tenured professor at the School of Fine Arts in Murcia, since 1989 Ortuño has regularly exhibited his videos and installations. His work explores three conceptual axes: gender and social identity, the media as a reflection of the social, and public art as a means for social protest. He bases his work on the existing links between sculptural elements and the implications of image, sound, the time vector and the impression of movement. Ortuño's works have been seen at Gasworks, London (2008); Museo Nacional Reina Sofía, Madrid (2006); Museo Patio Herreriano, Valladolid (2006); PhotoEspaña, Madrid (2004); Fundación Metrònom, Barcelona (2002); Museo de Arte Moderno de Buenos Aires (2000); and Centro Cultural de España, Lima (1999), among other places.
<http://www.pedrortu.com>

**Raquel Paricio**
A Fine Arts graduate, Paricio is currently devoted to art research and production. Her interests, related with her current research at the Polytechnic University of Barcelona (UPC), include the study of space, devices and interfaces helping to enlarge perception through work with applications of evolutionary hardware in artificial life. On this subject, she has exhibited or published at: Banquete, Centro de Arte Laboral, Transmediale, Planetary Collegium, Consciousness Reframed, Technoetic Arts, Leonardo on-line, IST, Mendel Art Gallery, Fundació Tapies, Museum of Contemporary Art, Chicago, receiving honorable mentions in VIDA 9.0 and Vida 11.
She co-directed the book *Computational Aesthetics 2007* and was co-president of the Aesthetical Computing Congress (June 2007) in Banff, Canada.
<http://www.evolvable.net>

**Platoniq**
A Barcelona-based collective comprising Susana Noguero, Oliver Schulbaum, Ignacio García and Joan Villa Puig, Platoniq was founded in 2001. Their work investigates the possible social uses of technology and networking in order to improve strategies of citizens' communication, self-training and organization. The results are innovative tools and methodologies for collective research, as well as an ample audiovisiual archive under free licences on Internet. Since 2003, Platoniq collaborates with the Center for Contemporary Culture in Barcelona and in recent years they have obtained two international prizes for their project, Burn station, a station to copy "copyleft" music, at the Transitio Festival in Mexico and the Transmediale Digital Culture Festival in Berlin.
They have presented their projects in leading festivals and national and international art centers such as the Ars Electronica Festival in Linz, the Image Center in Mexico City, the Tranmediale Festival in Berlin, the V2 Institute in Rotterdam, the La Friche Cutural Center in Marseilles, the Duolun Museum of Modern Art in Shanghai and the Congress of Electronic Art ISEA in Singapore.
<http://www.platoniq.net/>
<http://www.bancocomun.org>

**Diego Rasskin-Gutman**
Doctor of Biology (1995), he is the researcher responsible for the Theoretical Biology Group at the Cavanilles Institute of Biodiversity and Evolutionary Biology (ICBIBE) in Valencia. He studied at the Autonomous University of Madrid. His post-doctoral work (1996-2006) took him to the National Museum of Natural History in Washington DC; the Konrad Lorenz Institute for Evolution and Cognition in Alenberg (Austria); and finally, the Salk Institute in California. His current research covers various levels of biological organization such as early embryonic development and the breakdown of symmetry during embryogenesis; the generation of analytic methods for studying morphological transformations throughout evolution; evolutionary robotics; the thinking of chess experts' minds, and the relation between form and function in art and science.
<http://www.uv.es/cavanillas>

**Luis Rico**
An artist, designer and cultural producer, he is the co-founder and co-director of Medialabmadrid, a trans-disciplinary program specializing in the exploration of new no-lineal models of research, training, production and cultural diffusion at the Conde Duque Cultural Center (CCCD) in Madrid. Codirector the I International Festival of Art, Science and Technology: *Cibervisión*, at the CCCD (2002) and

the exhibitions projects *banquete_metabolismo y comunicación* (2003), *banquete_comunicación en evolución* (2005) and co-curator of *Digital Transit*, which was held at CCCD and co-produced by the Ars Electronica Center in Linz, and Medialabmadrid. He currently directs the R&D programme, *Nodos y Redes* on the ecophysiology of the creation and transfer of knowledge and the plataform Ebiolab.
<http://www.banquete.org>
<http://www.medialabmadrid.org>

**Víctor del Río**
Doctor of Philosophy by the UNED, he got his undergraduate degrees in Philosophy and Fine Arts at the University of Salamanca. He is currently professor of Contemporary Art History and Art Criticism at that university. He has published essays in various specialized publications and collective works, as well as the book *Fotografía objeto: la superación de la estética del documento.* He has edited other works, including *Estrategias críticas para una práctica educative en el arte contemporáneo,* published by the Museo Patio Herreriano, Valladolid, where he was chief of research and education.

**Arturo (Fito) Rodríguez**
Professor at the University of the Basque Country's (UPV) School of Fine Arts, he works independently with the collective Fundación Rodríguez, jury member for the *Show of Youth Art* in 1999 and for the *Video and Digital Arts Contest* (Injuve) in 2000. He is a member of the international jury for the MAP program, the European Observatory of New Artistic Expressions (Pépinières grants), and curator of the following exhibitions, among others: *Beste Bat: una Mirada al Rock Radical Vasco* (Sala Rekalde, Bilbao), *Stand by TV* (Caixaforum, Barcelona), *Panel de Control: Interruptores Críticos para una Sociedad Vigilada* (Centro de Arte de Sevilla) and *Spots Electorales: el Espectáculo de la Democracia* (Palau de la Virreina, Barcelona).
<http://www.fundacionrdz.com>

**Miguel Ángel Rodriguez**
He received his undergraduate degree in Biology (1984) and his doctorate in Ecology (1992) at the Complutense University of Madrid. He is now a tenured professor at the University of Alcalá, where he directs the Department of Ecology. Much of his research focuses on describing space-time patterns of biodiversity variations at different levels of biological organization and detecting the ecological, anthropogenic and evolutionary processes associated with those patterns. At the present time, he is especially interested in certain aspects of the bio-geography of conservation and macro-ecologies. He as directed various research projects as well as a program for inter-university educational cooperation in Equatorial Guinea.

**Salvador Rueda**
He has undergraduate degrees in Biology (1976) and psychology (1980) and diplomas in Environmental Engineering (1981) and Energy Engineering (1984). He directs the Urban Ecology Agency in Barcelona. He had administrative posts in planning for the Drainage and Residues Councils at the Regional Government of Catalonia (1992-2000). He developed an urban ecology program and was director of Integration of Programs to Revitalize Barcelona's Ciutat Vella (1990-1992). He was Chief of Environmental Services for the Barcelona City Government (1986-1990) and of Environmental Services for the City Government of Sant Adrià de Besòs (1980-1986). He was a member of the European Community's Group of Urban Environmental Experts (1994-2000). He is the author of various articles and publications including: *Libro verde de medio ambiente urbano* (Ministerio de Medio Ambiente, 2006), *Estrategia española de medio ambiente urbano* (Ministerio de Medio Ambiente, 2006).

**Francisco Ruiz de Infante**
He received his undergraduate degree in Painting and Audiovisuals at the School of the Arts of the University of the Basque Country. He is now a professor of "outside-the-format" art at the ESAD in Strasbourg. He works mostly in the areas of video and audiovisual installations, with an abundance of spaces that are displaced or in an apparent state of construction. His works are often disquieting, submerging viewers in an experience that leads them through the corners of memory and the unconscious. He has shown important projects at institutions such as the Musée d'Art Moderne de Paris, Museo Nacional Centro de Arte Reina Sofía, Madrid, the Guggenheim, Bilbao, the Maison de l'Image, Geneva, Blaffler Gallery, Houston, the Kunst-Halle of Bonn, La Panera de Lérida, Metrònom in Barcelona, the Cervantes Institue of Casablanca, La Gallera in Valencia and Art Statement at Artbasel33 by way of galería Elba Benítez, Madrid.
He is currently preparing a complex exhibition project with the Telefónica Foundation of Buenos Aires (March-July 2009).

**Fernando Sáez Vacas**
Senior professor at the Polytechnic University of Madrid's Superior Technical School of Telecommunications Engineering, he is ex-president of the Spanish chapter of the IEEE Computer Society (1984-2002) and ex-president of the Spanish Association of Computing and Automation (1989-1993). He won the Fundesco Prize for essays (1989) and for research (1996) and the National Computing Prize in 2006. One of his main research areas is the "Sociotechnology of Information." It focuses on the human and social revolution that is currently taking place because of the technological infrastructure known as the *Universal Digital Network,* in which social and technological aspects are practically inseparable.

**Abraham San Pedro**
A graduate in Political Science and Sociology from the Complutense University of Madrid, he earned his master's degree in Political Communication at the same university, and in Cultural Management at Carlos III University. His professional work focuses on the cultural management of art and new technologies. He has collaborated with Medialabmadrid and on earlier editions of *banquete_*. His interests are biological, political and social transformations generated by new digital culture.

**María Santoyo**
A graduate in Art History from the Complutense University of Madrid, she now works as an exhibition coordinator at Canopia, a cultural management firm specializing in photographic archives. An independent curator and critic, she

has carried out various projects focused on the image and its relation to the systematization of memory and collective desire, with a special interest in manifestations of proto-technological art. She is a tenured professor of Current Art and coordinator of the Visual Arts Diploma at the Superior Institute of Arts.

**Agueda Simó**
She is a multimedia artist who investigates the interaction between art and science using new technologies. She started her artwork in the field of video developing an aesthetic that led her to work with computer graphics, and afterwards on interactive installations and virtual reality. Her work has been exhibited and published internationally in museums, festivals and conferences such as SIGGRAPH, Imagina, ArtFutura, ICMC, etc. Her virtual reality installation, *Microworlds, Sirens and Argonauts*, is exhibited in the permanent collection of the Museum of Science of San Sebastian. She holds a doctorate in Fine Arts and combines her artistic work with research and teaching. She has taught at he University of Southern California, at the California Institute of the Arts (CalArts) and the University of the Basque Country, among others, and she is currently director of the Program in Multimedia Design at the University of Beira Interior.
<http://www.aguedasimo.net>

**Monica Solé**
A doctor of Biology, she carries out research in the field of environmental microbiology, evolution, immunology and virology. She was responsible for science outreach programs and contents at the Cosmocaixa Science Museum (Barcelona) and science advisor to Medialabmadrid. She now works as a freelance professional focusing on projects to make science more widely known to the general public.

**Ricard Solé**
A doctor in Physics from the Polytechnic University of Catalonia and a graduate in biology from the University of Barcelna, he is a professor at Pompeu Fabra University in Barcelona, where he directs the Complex Systems laboratory. His research in this field span a spectrum from theoretical ecology to the study of social and language networks, and others as complex at traffic and Internet itself. He is an external professor at the Santa Fe Institute, New Mexico, United States, and a member of the Council of the European Society of Complex Systems. He received the City of Barcelona Prize for Scientific Research for his work, *Least Effort and the Origins of Scaling in Human Language.*

**Imma Tubella**
A doctor of Social Sciences, she is Professor of Audiovisual Communications Studies (UOC) in the postgraduate programme of Frontière et Identité at the University of Perpinyà and a member of the advisory councils of Canal Barça, Telefónica, Franco-Catalan Transfrontalier, the University of Perpinyà and the advisory council of the president of the Generalitat of Catalonia for audiovisual activity in Catalonia. She was Vice-Rector of Research at the UOC (1999-2003); Vice-President of the Internet Interdisciplinary Institute (IN3) (2000-2003); member of the board of directors of the Catalan Corporation of Radio and Television (2000-2003) and of the Advisory Committee for Telecommunications and the Information Society for the Generalitat of Catalonia (2000-2003), as well as vice-president of the Catalan Society of Communciation at the Institute of Catalan Studies (1995-2000), among others. She is the author of various books on communications and identity.

**Alfonso Valencia**
After completing his doctorate in Molecular Biology at the Autonoma University of Madrid, he carried out postdoctoral studies in the United States and Germany (EMBL). He was director of the Protein Design Group at CNB-CSIC (1994-2006) and has been director of the Programme for Structural Biology and Biocomputing for the National Centre of Oncology Research since 2006. Since 2003, he directs the National Biocomputing Institute. A founding member of the International Association of Biocomputing (ISCB) and of the European Society of Biocomputing (ECCB), he is also the executive editor of *Bioinformatics* magazine. His scientific interests focus on the development of computing techniques for studying the organization and evolution of molecular systems in the context of genomics as applied to biomedicine. He has published over 100 scientific articles in this field (H-factor 45). He has also collaborated on projects such as GNOM.

**Vicente Verdú**
A writer and journalist who earned his doctorate in social sciences at the Sorbonne, he is a member of Harvard University's Nieman Foundation. He writes regularly in *El País,* the newspaper where he has been comment editor and arts editor. Among his books are: *Noviazgo y matrimonio en la burguesía española*, *El fútbol, mitos, ritos y símbolos*, *El éxito y el fracaso*, *Nuevos amores, nuevas familias*, *China Superstar*, *Emociones* and *Señoras y señores* (Espasa Essay Prize), *Si usted no hace regalos, le asesinarán* (Anagrama, 1971), he also published the short-story collections, *Héroes y vecinos* and *Cuentos de matrimonios* and the essays, *Días sin fumar* (a finalist for the Anagrama Essay Prize in 1988) and *El planeta americano* (Anagrama Essay Prize, 1988). He has also published *El estilo del mundo: la vida en el capitalismo de ficción* (Anagrama, 2003) and *Yo y tú, objetos de lujo* (Debate, 2005). His most recent books are *No ficción* (Anagrama, 2008) and *Passé composé* (Alfaguara, 2008).

**Remedios Zafra**
A writer and director of the Art, Gender and Cyberspace Research Group, she is a tenured professor at the University of Seville. She has a doctorate in Philosophy and higher studies in Art and Social and cultural anthropology. She has received various prizes for her essays on digital culture, including the Caja Madrid National Essay Prize for *Netanas,* the Research Prize of the Leonor de Guzmán Chair for *Habitar en (punto)net* and the Carmen de Burgos National Essay Prize for *Las cartas rotas: espacios de igualdad y feminización en Internet.* She is the author of numerous articles on net art and cyber-feminism and director of the magazine, *Mujer y Cultura Visual.* She has curated various art projects for the web.

## TECHNICAL DATA

***Social Synthesizer_Prototype,* 2008**
**Aetherbits (Mariela Cádiz, Kent Clelland, Denis Lelong)**
Interactive audiovisual a simultaneous on-line & on-site composition for new media.
<http://www.aetherbits.net>

***Canal*MOTOBOY*, 2007-2008**
**Antoni Abad**
Net art. Audiovisual documentation, random projection and tactile kiosk, two 4.000 ANSI LUMEN projectors, two DVD players and a map dispenser.
Organization: Centro Cultural de España and Centro Cultural São Paulo.
Sponsorship: Sociedad Estatal para la Acción Cultural Exterior de España.
Programming: Eugenio Tisselli.
Programming of the tactile interface: Lluís Gómez, Hangar Barcelona.
<http://www.zexe.net/SAOPAULO>

**Canal*****ACCESSIBLE / GENÈVE*ACCESSIBLE*, 2006 and 2008**
**Antoni Abad**
Net art. Audiovisual documentation, random projecton, two 4.000 ANSI LUMEN projectors, two DVD players.
Organization: Ville de Genève, Association Handicap Architecture Urbanisme, Centre d'Art Contemporain de Genève.
Sponsorship: Swisscom, Prohelvetia, Migros, Sociedad Estatal para la Acción Cultural Exterior de España.
<http://www.zexe.net/BARCELONA>
<http://www.zexe.net/GENEVE>

***Credulous*, 2009**
**Eugenio Ampudia**
Interactive installation. Projector, webcam, video camera, computer, furnishings and carpets forming the word *crédulos*.
Edition of 3, variable dimensions.
Courtesy of Titto Ferreira.
Production: Artempus.
Programming: Ñito Baena and Arturo Batanero.
<http://www.eugenioampudia.net>

***Protomembrane*, 2006**
**Marcel·lí Antúnez**
Lecture/ interactive action. 40-minute documentary videoprojection.
Author, performer and drawings: Marcel·lí Antúnez.
Video editing: Valentina Mottura.
Animation: Liliana Fortuny.
Programming: Matteo Sisti Sette.
Music: Alain Wergifosse.
Photography: Carles Rodríguez.
Video: Lucía Egaña Rojas, Francis Gómez de la Cruz.
Lighting design: Oriol Ibáñez.
Graphics assistants: Wahab Zeghlache, Emi Martín, Ana Fernández de Sevilla Fontanet, Oriol Corbella, Merlí Borrell, Dídac Valldosera.
Props: Ruth Aleu, Álvaro Sosa.
Models: Lucía Egaña Rojas, Emi Martín, Perla Mesa, Giulia Mattioli, Adelaida Antúnez, Àlvar Antúnez, Marcel·lí Antúnez.
Joy-dreskeleton: Héctor López.
Technical production: Oriol Ibáñez.
Technical production assistant: Lucía Egaña Rojas.
Executive production: Eva Vilaró Móra.
Production: Panspermia, S. L.
Collaborations: ICIC (Institut Català de les Indústries Culturals), INAEM (Instituto Nacional de las Artes Escénicas and de la Music, Ministerio de Cultura, España), ICUB (Institut de Cultura de Barcelona), D-lab (Dedale, Paris), Arcadi (Paris).
<http://www.marceliantunez.com>

***Sequences 24*, 2005-2008**
**Pablo Armesto**
Installation, fibre optic, fiberglass, neoprene blanket and power supplies. 24 panels approximately 44cm x 220cm each.
Scientific advice: Fundación Genoma.
Thanks: Alfonso Valencia.

***Luci. With No Name and No Memory*, 2008**
**José Manuel Berenguer**
Interactive installation.
Courtesy of Colección Beep-Data Logic and Galería Llucia Homs (Barcelona).
Thanks: La Agencia.
<http://www.sonoscop.net/jmb>

***Observatory*, 2008**
**Clara Boj, Diego Díaz**
Interactive installation. Mobile installation, tracking tower, video screen, display, variable dimensions.
Collaboration: Escif.
<http://www.lalalab.org>

***Tangle*, 2008**
**Daniel Canogar**
Installation. Projector, 24 zooms, 24 slides, electronic trashes, variable dimensions.
<http://www.danielcanogar.com>

***Other Geologies 9*, 2005**
**Daniel Canogar**
Digital photography. Photo-mural, variable dimensions.
<http://www.danielcanogar.com>

***Vacuum Virtual Machine*, 2008**
**Álvaro Castro**
Installation of *software art*. Flat screen, cpu, variable dimensions.
With the collaboration of Ebiolab, Instituto Nacional de Bioinformática-INB and Next Limits Technologies.
Thanks: Luis Rico and Alfonso Valencia.
<http://www.alvarocastro.es>

***The E Day for Energy*, 2008**
**Alfredo Colunga**
Net.art. Cooperative on-line project.
Thanks: 3D Maker
Produced by: LABoral Centro de Arte y Creación Industrial, with support from Caja Rural de Asturias.
<http://www.edayforenergy.org>

***Air, Sound, Power. Social Control Technologies with Sound*, 2008-2009**
**Escoitar**
Interactive installation and collective production workshop. Computer, tactile sensors, projector, interface on a stand and audio.
Thanks and scientific support: Grupo de Investigación DX7 Tracker, Universidad de Vigo.
With the collaboration of Ateneo Obrero de La Calzada, Gijón and ZKM Karlsruhe.
<http://www.escoitar.org>

***Tecura 4.0*, 2005-2009**
**Evru**
Net art, graphic work and workshop.
Thanks: MNCARS.
<http://www.tecura.org>



***GoogleGram: Ozone,* 2005**
**Joan Fontcuberta**
Digital photography. Chromogenic printing, 120 x 160 cm.

***GoogleGram: Prestige*, 2007**
**Joan Fontcuberta**
Digital photography. Chromogenic printing, 120 x 160 cm.

***All the Stories*, 2001-2009**
**Dora García**
Net art. Weblog.
Thanks: Aleph and José Luis Brea.
<http://www.doragarcia.net/insertos/todaslashistorias/weblog/>

***X-Devian. The New Technologies to the People System*, 2003**
**Daniel García Andújar**
Interactive installation and workshop.
<http://www.x-devian.com>
<http://www.danielandujar.org>

***The Intention*, 2008**
**Marta de Gonzalo, Publio Pérez Prieto**
Installation and workshop. Four audiovisual works DV (20'-32'-16'-12') and four wood studies 155 x 144 x 202 cm. with built-in screens.
Project produced with Francisco de Zurbarán grants from the Consejería de Cultura de la Junta de Extremadura, and Contemporary Creation Grants from the Área de Las Artes, Madrid City Council.
<http://www.martapublio.net>

***Wikiplaza / Plaza de las Libertades, Seville*, 2006**
**Hackitectura.net**
Graphic documentation of the architecture project carried out by Morales de Giles Architects and Esther Pizarro.
<http://www.mcs.hackitectura.net>

***Emerging Geographies*, 2007**
**Hackitectura.net**
Studio, action and videodocumentation.
*Infiltración nuclear*. Camera and editing: Carl Biosmark.
*Clausthome&Valdecaballeros.* Camera and editing: Carl Biosmark.
*C.N.V. 360.* Camera and editing: Carl Biosmark.
*La Arrancada.* Camera and editing: Estrébede and Josean Llorente.
*Moebius Industrial Surfing*. Camera: Alex Muñoz.
Editing: Manu Molina and Pablo de Soto.
<http://www.mcs.hackitectura.net>

***José, an Autistic Robot*, 2007**
**Ricardo Iglesias**
Robot action. Robot *roomba* (33,65 x 7,03 cm), ultrasound and infrared sensors, groups of LEDs of different colors, wireless video camera, variable dimensions.
Programming and development: Gerald Kogler, Mario Ruiz Aldano.
Production carried out with a Madrid Procesos07 grant from AVAM.
<http://www.mediainterventions.net>

***Madrid Mousaic*, 2005**
**Influenza (Raquel Rennó, Rafael Marchetti)**
Interactive installation. Processing, PC, 20W loudspeakers, microphone, flat screen.
A project in collaboration with Asociación Cultural Banquete and MediaLabMadrid.
<http://www.influenza.etc.br>

***Terre di Nessuno: Quicksand*, 2002-2009**
**Concha Jerez and José Iges**
Interactive installation. Net.art and video. Computer, connection to Internet, tres projectores.
Video recording: Concha Jerez.
Video editing: Concha Jerez, Pedro López.
Audio montage editing and mixing: José Iges.
Game page design: Concha Jerez, José Iges, Pedro López.
Computer programming: Pedro López.
Voices: María Jesús Álvarez, Pinotto Fava.
Project carried out with a grant from the Dirección General de Bellas Artes del Ministerio de Cultura.
<http://www.joseiges.com>
<http://www.conchajerez.com>

***mur.muros / Dystopia # 2* , 2007-2008**
**Kònic Thtr (Rosa Sánchez, Alain Baumann)**
Interactive installation, variable dimensions.
Collaborations: Martí Sánchez Fibla for the development of *terra_i_vida* software.
Ariadna Alsina for the development of audio analysis software.

Asociación Koniclab, Creació Contemporánia i Noves Tecnologíes, Instituto de Investigación en Inteligencia Artificial (IIIA) del CSIC, Departament de Cultura de la Generalitat de Catalunya.
Thanks: Adolf Alcañiz, Carles Fusté, Marta Gracia, Marta Pol i Rigau, Museu d'Història de la Ciutat de Girona, Ajuntament de Girona, Hangar, Centre de Creació d'Arts Visuals i Multimedia.
<http://www.koniclab.info>

***Light Modulator 3.0*, 2006-2008**
**Laboratorio de Luz**
Interactive installation. Vocal control of light and sound, variable dimensions.
Participants: Amparo Carbonell, Salomé Cuesta, Maribel Doménech, Dolores Furió, Carlos García Miragall, Trinidad Gracia, Moisés Mañas, Emilio Martínez, María José Martínez de Pisón, Emanuele Mazza, Dolores Piqueras, Francisco Sanmartín, Ulrike Gollner and Jeldrik Schmuch.
Thanks: Universidad Politécnica de Valencia.
<http://www.laboluz.org>

***NostalG2 // L'AGE D'OR NFO.EXE*, 2003-2008**
**Joan Leandre**
Net.art, Installation with projection, cpu with DOS application for a terminal.
<http://www.retroyou.org>

***TVLATA*, 2007**
**Neokinok TV**
Installation. Two monitors, DVD in 10-second loop, computer with connection to Internet, photos and plotters, variable dimensions.
TVLATA team: Jacob, Jairo, Luciano, Edvaldo, Ricardo, Eduardo, Anderson, Elvis, Everton, Mauro, Josinan, Tiago, Walber, Jefferson, Juliana, Leonaldo, Bruno and Josué.
Neokinok TV team: Daniel Mirakle, Félix Pérez Hita, Mónica Hernández, Susana Zaragoza e Íñigo García, in collaboration with the non-profit organization Bagunçaço.
<http://www.neokinok.tv>
<http://www.tvlata.org>

***Untitled (science fiction)*, 2001**
**Marina Núñez**
Installation. Nine images in fluorescent paint on methacrylate, black light, installation, variable dimensions.
Courtesy by the Comunidad Autónoma de la Región de Murcia. Museo de Bellas Artes de Murcia.
Courtesy by the Galería Salvador Díaz, Madrid.
<http://www.marinanunez.net>

***Untitled (science fiction)*, 2001**
**Marina Núñez**
Installation. Four boxes, fluorescent paint on wood and cables, black light, 127 x 127 x 75 cm.
Colección de Arte Contemporáneo de Castilla and León, Junta de Castilla and León. Departamento de Artes Visuales.
Courtesy by the Galería Salvador Díaz, Madrid
<http://www.marinanunez.net>

***Ocaso*, 2007**
**Marina Núñez**
One-channel video, sound, 56''.
Sound space: Iván Solano.
<http://www.marinanunez.net>

***White on Black*, 2004**
**Pedro Ortuño**
Video-installation, 12'
<http://www.pedrortu.com>

***POEtic-Cubes*, 2007-2008**
**Raquel Paricio, J. Manuel Moreno**
Robot action. Interactive installation, Nine autonomous robots with bio-inspired capacities (50 x 50 x 50 cm each). POEtic-Cubes was carried out with the collaboration of the Departament de Cultura i Mitjans de Communicació de la Generalitat de Catalunya-EADC and the support of: Advanced Hardware Architectures (AHA) Group; Department d' engingeria electronic de la Universitat Politècnica de Catalunya (UPC) and Neàpolis, a space for technology and ideas.
<http://www.evolvable.net>
<http://www.poetictissue.org>

***Bank of Common Knowledge (BCC)*, 2006-2009**
**Platoniq**
Participatory installation, performance and workshop. Two monitors, DVD, connection to Internet, plotter, and bulletin board.
<http://www.platoniq.net>
<http://www.bancocomun.org>

***Queen*, 2007**
**Francisco Ruiz de Infante**
Installation. A table and a wooden chair, a wooden prothesis-hoder for lamps, a camera and cables, a florescent lamp, white electric cable and plugs, a surveillance camera, a control monitor, two photographic prints (from drawings by Santiago Ramón y Cajal) on 8mm plexiglass ("neuronas 2005-07" 93 x 67 cm each).
Courtesy by Elba Benítez, Madrid.
<http://www.mediatecaonline.net/ruizdeinfante>

***Reflecting JCC. Brain Research II*, 2007**
**Águeda Simó**
Interactive installation, variable dimensions.
Collaborations:
JCC_MartaMur_Malpertius_ L'Mono_Performers.
MartaAyala_Projections_setUp.
AlbertoTorcal_Drawings.
EnrikeHurtado_Sound.
jm_BlackCirclesTexts.
EveTramullas_CaveVideo.
LucíaSimó_Concepts_Neuroscience_Bioethics.
MariMar_Production.
<http://www.aguedasimo.net>

## EXHIBITION

**Produced and Organized by**
LABoral Centro de Arte y Creación Industrial
State Corporation for Spanish Cultural Action Abroad (SEACEX)
ZKM | Center for Art and Media Karlsruhe
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Instituto Nacional de Bioinformática
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**Insurance**
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## ZKM | Center for Art and Media Karlsruhe

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